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DECIDUOUS FRUIT AND TREE NUT RESEARCH

of the
United States Department of Agriculture
and cooperating agencies.

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This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report, a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
December 1, 1962

OTHER COMMODITY AND FUNCTIONAL REPORTS

A progress report similar to this one is prepared for use by each of the following research and marketing advisory committees:

Citrus and Subtropical Fruit	Sheep and Wool
Cotton and Cottonseed	Sugar
Dairy	Tobacco
Forage, Feed and Seed	Vegetable
Forestry	Economics
Grain	Farm Equipment and Structures
Livestock	Food and Nutrition
Oilseeds and Peanut	Food Distribution
Potato	Home Economics
Poultry	Soils, Water and Fertilizer
Rice	Transportation and Storage

Two additional reports of progress are prepared in order to make available the complete research program. They are:

Ornamentals and Other Miscellaneous Commodities
Other Research — Cross Commodity

ORGANIZATIONAL UNIT REPORTS

All of the material in the commodity and functional reports listed above is the same as that found in the 20 division and 3 service research reports listed below.

Agricultural Research Service (ARS)

Agricultural Engineering
Animal Disease and Parasite
Animal Husbandry
Crops
Entomology
Soil and Water Conservation
Utilization -- Eastern
Utilization -- Northern
Utilization -- Southern
Utilization -- Western
Human Nutrition
Clothing and Housing
Consumer and Food Economics

Agricultural Marketing Service (AMS)

Market Quality
Transportation and Facilities

Economic Research Service (ERS)

Farm Economics
Marketing Economics
Economic & Statistical Analysis
Foreign Development and Trade
Analysis
Foreign Regional Analysis

Other Services

Farmer Cooperative Service (FCS)
Forest Service (FS)
Statistical Reporting Service (SRS)

A copy of this report or any of the others listed above may be requested from Roy Magruder, Executive Secretary, Deciduous Fruit and Tree Nut Research and Marketing Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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INTRODUCTION

This report deals with research on all kinds of deciduous tree fruits, small fruits, grapes and edible tree nuts. It covers Farm Research, Utilization Research, Marketing Research, Economic Research, and Nutrition and Consumer-Use Research of the U.S.D.A. and cooperating agencies. Only a brief description of the related work of the State Experiment Stations and industry is included.

Under each of the Problem Areas there is a statement describing the Program of work underway and the professional man-years devoted to the major kinds of research included. The relative scope of the total research effort on deciduous fruits and tree nuts is indicated by the approximate number of professional man-years employed: 172 by U.S.D.A., 276 by the State Experiment Stations, and about 400 by industry and other organizations.

A brief report of Progress and significant findings for U.S.D.A. and cooperative programs is given for each phase of the research program.

A considerable amount of basic cross-commodity and functional research that will supply new knowledge applicable to the fruit and tree nut problems is not included in this report. Such research is included in the functional reports such as "Economics," "Soils, Water and Fertilizer," and in the "Other Research" report.

Research by U.S.D.A.

The farm research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology and Agricultural Engineering Divisions of the Agricultural Research Service; and in fiscal year 1962 involved 87 professional man-years.

Utilization research deals with methods of preservation of these commodities through canning, drying, freezing, or combinations of these methods and also with the origination of new forms of food products or combinations of fruits and nuts with other foods. It is also concerned with improved equipment and processes. The work is done at the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania; at the Western Utilization Research and Development Division, Albany, California; at WURDD laboratories at Pasadena, California; and at Puyallup and Prosser, Washington; and under contract with State and foreign country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area. In fiscal year 1962 the work involved 39 professional man-years.

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by the Market Quality and Transportation and Facilities Research Divisions of the Agricultural Marketing Service and utilized 25 professional man-years in fiscal year 1962.

Economic research is concerned with marketing costs, margins and efficiency; market potential, supply and demand; outlook and situation; and improving marketing through research with farmer cooperatives. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service; by the Standards and Research Division of the Statistical Reporting Service; and by the Marketing Division of the Farmer Cooperative Service. Approximately 15 professional man-years were devoted to this work in fiscal year 1962.

Nutrition and consumer-use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation and care in homes, eating establishments and institutions. This work is done by the Divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service, and in fiscal year 1962 involved 6 professional man-years.

Research by State Experiment Stations

There is included under each Problem Area a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research.

Consolidating this information for the entire field of interest, we find that in fiscal year 1962 a total of 276.2 professional man-years were spent by the State Agricultural Experiment Stations on deciduous fruit and tree nuts research.

Deciduous fruit and tree nut research in 1962 was in progress in 50 of the 53 State Agricultural Experiment Stations. Studies underway were carried out by research workers in Departments of Horticulture, Agricultural Engineering, Agricultural Economics, Entomology, Plant Pathology, Food Technology, and Home Economics. Deciduous fruit and tree nut research at the State Agricultural Experiment Stations in 1962 included 7.5 man-years on the agricultural engineering phases of crop harvesting

and handling operations and equipment, crop preparation and farm processing, and buildings for fruit storage; 126.6 man-years on tree fruit culture, breeding, diseases, and variety evaluation; 59.9 man-years on small fruit culture, breeding, diseases, and variety evaluation; 7.2 man-years on tree nut culture, breeding, diseases, and variety evaluation; 47.2 man-years on deciduous fruit, tree nut, grape, and berry insects; 11.2 man-years on utilization research and development; 1.7 on human nutrition and consumer-use research; and 16.6 man-years on market quality research. In addition, considerable related research was conducted on problems which could not readily be identified with specific fruit and nut crops. This research included work on weed control; nematode identification, physiology, and control; crop introduction and evaluation; marketing economics; improvement of crop estimating procedures; and improved marketing operations through research with farmer cooperatives.

No details on progress of State station research are included in this report except as such work is cooperative with U.S.D.A.

Research by Industry and Other Organizations

The 400 professional man-years estimated for calendar year 1961 as industry's participation in research on deciduous fruits and edible tree nuts are employed primarily by food processors and distributors, food industry and trade associations, food container and equipment suppliers (over half the total is in these three categories), marketing equipment and facility manufacturers, chemical and fertilizer companies, package and container manufacturers, market research institutes and corporations, nurserymen, orchardists and grove owners.

A number of food processing companies and wholesale and retail distributors are presently conducting research in various phases of products and process development in frozen, canned, and dried tree fruits and nuts. These studies cover a wide field directed toward the securing of patents or secret processes that can be exploited rather quickly to the best interests of each company.

The canning, freezing, and dehydrating industries each maintain an association with a technical staff and either do research in their own laboratories or support research at U.S.D.A. laboratories, universities and other organizations. Some of their research is of a basic nature but most of it is of an applied nature and the results are made available in trade and scientific journals.

Allied industries and suppliers to the food processing industry maintain excellent laboratories and large research staffs to provide technical information to the industry. Most of their research is of a trouble-shooting nature although many valuable contributions to the store of basic knowledge have been made by this group.

Marketing equipment and facility manufacturers also make sizeable contributions to research on the development of equipment for handling fruits and nuts on the farm or orchard, into and out of packing houses, transportation vehicle, wholesale distribution center and in the retail establishment as well as research on the containers in which it is moved and on the transportation vehicles from which it moves from one point in the distribution channel to another.

Chemical and fertilizer companies make a significant contribution in research on the development of new materials or combinations of materials to produce more efficiently, high quality fruits and tree nuts through better nutrition of the growing plant, control of diseases, insects, nematodes, weeds and the regulation of growth processes through use of growth regulator substances such as fruit set thinners, stop-drop chemicals, bloom retarders, etc.

Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development, and interregional and intermarket competition. The results are available only to the purchaser.

There are a few private breeders of deciduous fruits and tree nuts and a number of the larger nurserymen spend considerable time and money in the search for, and testing of, new varieties in the major production areas; sometimes on their own acreage, but usually in cooperation with some grower.

It is very difficult to estimate the contribution of growers to our overall research effort on deciduous fruit and tree nuts. Certainly, in the field of production his help is indispensable for most of the laboratory research results must finally be confirmed by orchard scale experiments. The grower cooperates with the U.S.D.A., State Experiment Stations and suppliers of many materials and equipment, usually without compensation except for the experience and knowledge gained.

Industry's cooperation in supporting research on deciduous fruits and tree nuts in the form of grants, gifts or loans of materials, equipment and facilities at Federal and State stations has contributed greatly to its success.

No details on progress of industry research are included in this report except as such work is cooperative with U.S.D.A.

Examples of Recent Research Accomplishments
by USDA and Cooperating Scientists

Sevin for Apple Thinning. A new, more reliable apple-thinning chemical, Sevin (1-naphthyl-N-methyl carbamate) introduced as an insecticide, was found to be an excellent thinning agent when used at 1.5 pounds per 100 gallons of water, 15 to 25 days after full bloom. The response to Sevin appears more constant in the different environments than that to other chemicals.

Harvesting Tart Cherries. In cooperation with Michigan State University, equipment and methods have recently been devised to reduce labor requirements and costs for harvesting tart cherries. Hydraulically activated shakers remove 95 percent of the cherries from trees. Remaining cherries are mainly undersized and lack maturity. Several types of portable frames catch the cherries. In 1962, 30 growers used this harvesting equipment in conjunction with the previously developed water handling and transport system. Rates of 4,000 pounds per hour and as high as 23 trees per hour were obtained. Considering conditions existing in many orchards, mechanical harvesting should reduce labor requirements by 75 percent and harvesting costs by 50 percent.

Dehydrofreezing of Fruits and Vegetables Gains Broad Acceptance.

Dehydrofreezing, a method of food preservation developed by Department scientists whereby foods are partially dehydrated and then frozen, is now in commercial use. Several million pounds of dehydrofrozen apples are being produced each year for use in commercial bakeries. Dehydrofrozen peas, carrots, and potatoes are being manufactured in rapidly increasing tonnages and are becoming important export items. Three million pounds of dehydrofrozen pimientos were produced last year for use in cheese products. A large food concern has just completed a market test of dehydrofrozen baby foods, including fruits, vegetables, soups, meat dinners, and puddings.

In the process, dehydration is conducted to remove at least half of the water present to avoid the irreversible quality damage that occurs during late stages of complete drying. The reduction in product weight and volume achieved by partial dehydration results in large savings in costs of freezing, packaging, handling, and shipping. Fresh flavor, texture, and color are retained by keeping the product frozen. Less drip on thawing and easier moisture control during remanufacture are among the advantages of dehydrofrozen over conventional frozen foods. The fresh-product quality, the convenience and the relatively low cost of reconstituted dehydrofrozen foods assure expanding acceptance of dehydrofreezing as a method of food preservation.

Forecasting Storage Quality of Table Grapes. Decay is the limiting factor in grape storage. A procedure was developed and is now in commercial use whereby the storage quality of individual lots can be forecast shortly after harvest. Those with short storage potentials can then be marketed first while still salable, thus preventing unnecessary losses, and making for a more orderly marketing of the product. The principle should be applicable to other commodities as soon as the specific details for the different products are worked out. It has already been applied with considerable success to apples in the Northwest.

Marketing Apples in New Form Found Economically Feasible. The commercial possibilities of dehydrofrozen apple slices appear to be excellent in the baking industry. This commercial appeal arises from the fact that dehydrofrozen apples, with 50 percent of the weight and volume removed, compare favorably in quality with regularly frozen apples, yet incorporate some of the economic advantages of dehydrated products, such as savings in handling and shipping costs.

These results were obtained from extensive field surveys conducted during the year with bakers, brokers, and fruit processors. Favorable baker reaction was found, especially in large institutional and wholesale bakery operations where savings in transportation and storage are substantial. Today, there are at least eight commercial processors of dehydrofrozen apple slices, and other are investigating the possibilities, anticipating production. In addition, several national and regional chains have adopted this new product in their baking operations.

I. FARM RESEARCH

CROP INTRODUCTION AND EVALUATION Crops Research Division, ARS

Problem. One of the important needs in a more efficient agriculture is the development of improved planting material with resistance to insects, diseases, and climatic hazards; increased adaptation; and higher quality. There is a need to search out, introduce, and evaluate the widest possible genetic base of deciduous fruits and tree nuts from foreign and domestic sources that may be of value as varieties, rootstocks, or breeding materials.

USDA PROGRAM

The Department undertakes a continuing program of plant introduction, evaluation and maintenance. The research involves botanists, horticulturists and plant pathologists who are engaged in both basic and applied studies that will provide plant scientists and others with documented germ plasm.

Plant introduction is undertaken in both foreign and domestic fields, either through direct exploration or international exchange. Taxonomic and economic botanical research on world plant resources, development of national inventories of introduced stocks, coordination of foreign and domestic plant collecting, and botanical assessment of the results of crop utilization screening programs are conducted at Beltsville. Cooperative arrangements with the four regional projects provides for domestic explorations.

Preliminary evaluation of deciduous fruit and tree nut stocks is done at Beltsville, Maryland; Glenn Dale, Maryland; Experiment, Georgia; Miami, Florida; Chico, California; Geneva, New York; Ames, Iowa; and Pullman, Washington. It involves observations for specific characters needed in varietal improvement, development of potential new or improved rootstocks, quarantine propagation and indexing for viruses, and the maintenance of collections of important varieties. Regional station pathologists screen the introductions for disease tolerance. Federal, State, and private breeders cooperate in the early evaluation of introductions. Needs for additional breeding stocks are assessed by the research leaders at Beltsville, and become the basis for future plant exploration and introduction.

The Federal scientific effort devoted to research in introduction and evaluation of deciduous fruits and tree nuts is 4.8 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Information on the crop introduction and evaluation research for commodities by State Experiment Stations and industry is not available. For a summary statement covering all research by these agencies on crop introduction and evaluation, see page 441, in the Crops Research Division report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A collection of 85 grape selections from Italy was obtained for screening for resistance against disease. Domestic exploration in Alaska brought in 80 collections of small fruit material. Eighty-five grape stocks and 65 native or naturalized fruit trees were obtained from the Southern United States. In all, 500 fruit and nut stocks were introduced in 1961.

Research is undertaken on the propagation and testing of introductions of breeding stocks for currently grown fruits, and the preliminary trial of promising new fruits. In support of general fruit and nut crops research, 500 new introductions were received for propagation and 83 introductions were offered to Federal and State experiment Stations. Progress has continued in the virus-indexing program with stone fruit introductions. At the Glenn Dale Station a total of 169 introductions of almond, apricot, cherry, peach, and plum are presently being indexed. About one-half should receive the final inspection for the presence of viruses during 1962. Those which prove to be virus-free will be released for distribution at the end of the growing season.

Two sweet cherry varieties released from Chico, California, to growers during the year are the Moreau and Early Burlat. Both varieties ripen earlier in the sweet-cherry section of Central California than standard varieties and are in demand for planting.

Sweet cherry seedlings of two accessions reported to have some resistance to cherry leaf spot, Coccomyces hiemalis, were artificially inoculated at Glenn Dale, Maryland, during the spring of 1961. Those plants showing a moderate to severe incidence of infection were discarded. The resistant seedlings were transplanted to outdoor nurseries where they will be retested during 1962.

A cherry seed germination experiment conducted at the Glenn Dale Station showed that better germination was obtained from seed lots not fumigated. Seeds fumigated with methyl bromide at the recommended rate, with or without vacuum, germinated about equally well. No germination was obtained from seeds fumigated with ethylene oxide.

The undertaking of the development of national inventories of vegetatively-propagated economic plants resulted in a completed survey which documents some 6,500 apple varieties being held at State and Federal locations. This inventory provides information on varietal name, description, origin, value, and other pertinent information.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

New Crop Evaluation

Joley, L. E. 1960. Propagation in the genus Pistacia. Proc. of the Plant Prop. Soc., pp. 287-294.

TREE FRUIT CULTURE, BREEDING AND GENETICS,
DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Since stone fruits are widely grown throughout the United States and since the important commercial areas vary greatly in soil and climatic conditions, the research problems are variable. More research is needed on the reaction of varieties in different producing areas; breeding for improved qualities needed in different areas including the ripening at variable periods from the early to the late marketing seasons; basic information and control methods of disease organisms including virus diseases; development of hardy disease and nematode-resistant rootstocks; effects of climate on growth, yield, and fruit qualities; replanting of peaches in old orchard locations; thinning fruit with chemical sprays for improvement in quality and size; and chemical relation of nutrition to fruit quality in the different growing areas.

Apple and pear production is limited by the high cost of growing practices and lack of basic information on nutrition, rootstocks, basic physiology of growth, and disease control. In eastern United States, up to ten cover sprays are required to control diseases that reduce the foliage and scar the fruit. There is need for new rootstocks that will bring apples and pears into production earlier, will produce smaller trees with greater bearing surface and more light exposure, are not virus sensitive, and are winter hardy and disease resistant. Basic information is needed on the cause of apple bitter pit and other internal fruit disorders that initiate in the field. More precise information is needed on the basic physiology of fruit setting, fruit thinning, and growth physiology. New high-quality, early-maturing varieties are needed for the South and better dual-purpose varieties for the fresh fruit and processing industries in northern areas.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, plant physiologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of fruit-growers problems. Apple breeding research at Lafayette, Indiana, and at Madison, Wisconsin, and cultural and disease research at Wenatchee, Washington is cooperative with the respective State Experiment Stations as is pear disease research at Hood River, Oregon, and Riverside, California. Peach breeding and varietal evaluation research at Fresno, California, is in cooperation with Fresno State College and at Prosser with the Washington Agricultural Experiment Station; disease research at Clemson is cooperative

with the South Carolina Agricultural Experiment Station, and at Riverside in cooperation with the California Citrus Experiment Station. Plum breeding and evaluation research at Fresno is cooperative with Fresno State College and at Prosser with the Washington Agricultural Experiment Station. Cherry breeding and evaluation research at Prosser is cooperative with the Washington Agricultural Experiment Station; and disease research at Logan is cooperative with the Utah Agricultural Experiment Station. Apricot breeding research at Fresno is cooperative with Fresno State College.

Federal stations having deciduous fruit-tree research are Wenatchee, Washington; Fort Valley, Georgia; Mandan, North Dakota; and Beltsville, Maryland. Research at Wenatchee includes variety evaluation of pears; disease research with pear, peach, plum, and cherry; and cultural research with apple and pear. Breeding, variety evaluation, and cultural research is done with peach at Fort Valley, and with apple at Mandan. Research at Beltsville includes breeding and genetic studies of apple, pear, and peach; diseases of apple, pear, and peach; varietal evaluation of peach; and cultural studies of apple and peach.

The Federal scientific effort devoted to research in this area totals 23.5 professional man-years. Of this number 4.7 is devoted to breeding and genetics; 12.1 to diseases; 1.1 to variety evaluation; 5.4 to culture; and 0.2 to program leadership. Three 5-year P.L. 480 contracts are currently in effect: (1) with the Israel Ministry of Agriculture for studies on the physiology of rest (dormancy) and its application to fruit growing and providing funds with a \$73,667 equivalent of Israeli pounds; (2) with the Research Institute of Pomology, Skierniewice, Poland, for studies on growth promoting substances and inhibitors in apple trees during different stages of development and providing funds with a \$13,295 equivalent in Polish zlotys; and (3) also with the Research Institute of Pomology, Skierniewice, Poland for studies on epidemiology and control of apple scab and providing funds with a \$9,918 equivalent in Polish zlotys.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 126.6 professional man-years divided among sub-headings as follows: breeding and genetics 30.9, diseases 39.6, variety evaluation 10.4, and culture 45.7. The Indiana, Illinois, New Jersey, and New York State Experiment Stations have apple and pear cytology and breeding research concerned primarily with disease resistance and improving fruit quality. Peach breeding is conducted at several stations but has regional goals in addition to the usually desired horticultural tree and fruit characteristics as follows: in California to develop improved varieties for canning; in New Jersey, New York, and Michigan to develop winter-hardy and late-blooming (frost-resistant) varieties; and in certain of the Southeastern states to develop varieties with disease resistance and adaptability to mild winters.

Many states that do not have breeding programs carry on extensive variety evaluation trials. Investigations in many states are done to determine the cause, epidemiology, and control measures of a wide variety of bacterial and fungous diseases of tree fruits. Tree-fruit virus disease research is organized among the states under regional projects with the following general objectives: in the Northeast (NE-14) to study the cause and epidemiology of diseases primarily under field conditions; in the North Central region (NC-14) to index fruit plants for viruses and study their transmission; in the West (W-64) to isolate, purify, and reinoculate viruses, separate virus complexes into component agents, and make basic studies of infection; and an inter-regional project (IR-2) to coordinate the scientific efforts of the virus projects and to obtain, maintain, and increase virus-free fruit stocks for research and industry. Another regional project (NE-34) concerns the biology of plant-parasitic and soil-inhabiting nematodes, some of which are suspected to be seriously detrimental to fruit tree growth. Pear decline, its cause unknown, threatens the pear industry in the West and the Western Coastal States are studying extensively the potential cultural, environmental, insect and plant-pathogenic factors contributing to the disease. Due to the widespread commercial and home-garden culture of the various tree fruits, nearly every State Experiment Station does some research involving the cultural aspects of modern fruit production: soil management; temperature and water relations; propagation and stock-scion relationships; pruning and training; physiology of fruit set and development, and the use of a wide variety of chemicals in all phases of plant culture.

Industry and other organizations including orchardists conduct valuable research with deciduous tree fruits. The Agricultural Divisions of several chemical companies supply materials for evaluation as fertilizers, growth regulators and herbicides, soil fumigants, fungicides and insecticides, etc. Orchardists cooperate with chemical companies and other organizations including State and Federal Experiment Stations by furnishing land, fruit-plants and facilities, and the maintenance necessary for evaluation of chemicals, equipment, or plant materials. Certain growers, notably in California and Missouri, are breeding various kinds of tree fruits and introducing proprietary varieties. Estimated annual expenditures are equivalent to approximately 19 man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Apple. Late spring frost at both Wenatchee, Washington and Lafayette, Indiana seriously hampered the breeding and variety evaluation work. At Lafayette approximately 3900 seedlings in the scab resistance project were planted in 1961 and 74,000 seeds were produced from controlled crosses. Due to the freeze no new selections were made but 9 selections made in 1960 were propagated for second test.

At Blairsville, Georgia, 56 controlled crosses for early maturity yielded nearly 6000 seeds which were planted in 1962. At Mandan, North Dakota, 2200 seeds were obtained from controlled crosses of hardy apple varieties; 2100 seedlings from previous crosses were field planted; and 13 winter-hardy selections were made from progenies of previous hybridizations. At Madison, Wisconsin, resistance to apple scab was found to be single-gene controlled in McIntosh, Hyslop, Haralson, and Prairie Spy. Genetic studies with the fungus have suggested more linkage groups than expected from cytological chromosome counts.

2. Pear. At Beltsville, Maryland, controlled pollinated crosses involving 90 different parental combinations yielded almost 15,000 seeds. These will be evaluated in the nursery for resistance to fire blight, Erwinia amylovora and for horticultural characters.

Further screening of winter hardiness of named varieties and selections was conducted in the field plots and all pears under test including a number of varieties from the Medford, Oregon collection withstood a minimum of -26 degrees F. without serious winter injury.

At Mandan, North Dakota, crosses were made using high-quality winter-hardy varieties. Eight selections were made from earlier crosses and 1200 seedlings were field planted for evaluation.

3. Peach. Peach breeding research was continued at Fort Valley, Georgia; Fresno, California; Prosser, Washington; and Beltsville, Maryland; and limited breeding research and selection for winter-hardy varieties done at Cheyenne, Wyoming.

At Fort Valley emphasis was on development of early-ripening, low-chilling varieties that are firm fleshed, of high quality, and with attractive color and fruit shape adapted to the more southern peach areas. In 1961, 5500 young trees from crosses fruited for the first time and 423 saved for further evaluation. Nineteen of these were propagated for extensive test plantings and two selections are being considered for immediate introduction.

At Fresno emphasis is on development of high quality, firm, yellow varieties for mid- and late-season. About 2400 seedlings were planted for evaluation and two selections that ripen after Elberta were distributed among cooperators for further testing. A freestone variety ripening just ahead of Redglobe was introduced and named Redtop.

Peach and nectarine breeding at Beltsville emphasized bacterial spot resistance, and mid-season, or later, maturing varieties of high quality. Approximately 5000 hybrid peach seedlings were fruited and 76 were selected for further tests. Several promising selections were

made from the nectarine seedlings. One late-blooming selection which appears to be frost-resistant has been distributed to cooperators for evaluation. Another selection, maturing in mid-season but having more resistance to bacterial spot than Redglobe appears promising and is being further evaluated.

Breeding research at Prosser, Washington is directed toward bud winter-hardiness and quality peaches for shipment to fresh-fruit markets but which can also be processed. During 1961, 21 selections were made from among 1100 seedlings. Of the Prosser selections being evaluated at other experiment stations, one has been especially winter-hardy in Canada. Two others appear sufficiently promising that they are being considered for introduction.

At Cheyenne several selections were propagated and distributed for testing to other experiment stations in areas where winter hardiness is a problem.

Breeding, selection, and testing of nematode-resistant rootstocks was continued at Fresno, Fort Valley, and Beltsville. Greenhouse tests at Beltsville, cooperative with the Crops Protection Branch, expedited screening procedures for determining nematode resistance of both parent and seedling plants. F₂ seedling of F₁ selfs of Nemaguard have shown immunity to both the acrita and javanica races of the root knot nematode.

4. Plum. At Prosser, crosses were made using several Vineland (Ontario, Canada) selections and the large-fruited Edwards variety to obtain larger sized better quality fruits of the Italian prune type.

At Fresno, 5 high quality selections of Japanese type plums having large size, firm flesh, and good color, are being further evaluated.

At Mandan, research to improve quality in winter-hardy kinds, involved crosses between Japanese plum varieties and hardy native and "domestica" plums; promising selections were made and have been propagated for further testing.

5. Cherry. At Prosser, 20 sweet cherry selections were made from among 750 progeny of the recently introduced Chinook and Rainier varieties and sister seedlings. One selection, PL-687, is particularly outstanding because of its large, dark fruit as well as its hardiness and vigor. A new variety planting of 190 foreign and domestic cherry varieties was made for evaluation and to furnish germplasm for future breeding work. The new sweet cherry varieties, Chinook and Rainier, introduced by U. S. D. A. and Washington Agricultural Experiment Station in 1960, are in much demand by growers and were propagated to the limit of budwood available.

At Cheyenne, Wyoming crosses between several varieties of sweet and sour cherries have produced hybrids which are being evaluated for adaptability to the Northern Great Plains area.

At Mandan, winter-hardy selections of sour and Manchu cherry seedlings are being evaluated for adaptability to the areas of the Great Plains where winter temperatures are too low for sweet or sour cherries.

6. Apricot. At Prosser, from among 350 seedlings having Earlril and larger fruited varieties as parents, 4 selections having winter-hardiness and high fruit quality were made and are being further evaluated.

At Fresno, increased effort has gone into breeding to produce varieties with large-sized high quality fruit which do not develop pit-burn, suitable for processing and the fresh-fruit market. Seven selections have been made which have shown excellent promise and are being distributed to cooperators for further testing. Two of these are sufficiently superior that they should be considered for introduction.

B. Diseases

1. Apple. Apple Scab. Under epiphytotic disease conditions at Beltsville, the fungicides captan, dodine, and glyodin suspended in a non-phytotoxic oil failed to satisfactorily control scab on Red Delicious and Stayman apples. At Madison, Wisconsin fungus isolates of Venturia inaequalis which showed variable ability to produce infection also showed differential responses to amino acids and leaf extracts, but correlations between this response and pathogenicity was not demonstrated. Chromatographic assay of leaf extracts showed that a susceptible apple variety contained higher levels of arginine and asparagine than did resistant varieties. Six scab-resistant selections from Lafayette, Indiana, were tested at Beltsville and one (9A6-136) also exhibited powdery-mildew resistance in preliminary greenhouse tests.

Stem-pitting Virus. Studies at Logan, Utah, indicated that stem-pitting virus was transmitted to Virginia crab understocks by a large number of topworked infected apple varieties. Although Spy 227 lethal virus and stem-pitting virus commonly occur together in the in the same host but were differentially transmitted in greenhouse tests.

General Viruses. Positive transmission of a new apple virus, currently called "necrotic spot" was demonstrated in Wenatchee in Red Delicious and Jonathan. Symptoms of the disease vary from a few minute dark lenticel-like specks on the fruit surface to dark colored depressed necrotic areas involving 1/3 of the fruit area with serious malformation.

2. Pear. Fire Blight. For the sixth consecutive, and final, year field tests were conducted at Beltsville to control fire blight on Bartlett pear with sprays of Agrimycin 100 antibiotic. The sprayed trees had significantly less fire blight than unsprayed trees and fruits analyzed 117 days after the last spray application had no antibiotic residue in or on the fruit. Five chemicals showing activity against the fire blight organism Erwinia amylovora in the laboratory were ineffective to control the organism on Bartlett pear in the orchard. At Beltsville studies to determine the nature of fire-blight-resistance of the Magness variety indicates that two fractions in leaves, one organic and the other inorganic, are inhibitory to E. amylovora.

Pear Decline. At Wenatchee in cooperative studies with the Washington Experiment Station a chemical which appears to be a substituted purine was isolated from pear psylla homogenates and was found to cause phloem necrosis and wilting of bean plants. Work continues to determine the identity of the substance and evaluate its role in pear decline. Sixty-three species of woody plants, mostly rosaceous, were tested without success, at Riverside, California, as potential indicators of the pear decline causal agent. At Wenatchee, all known graft transmission tests using Bartlett on Pyrus communis or P. ussuriensis failed to indicate that a graft-transmissible virus is the primary cause of pear decline, yet in a plot of 149 Bartlett nursery trees on P. ussuriensis rootstock unprotected from natural influences except by insecticide sprays 17 died at the end of the 1st growing season and 44 more were either seriously declined and showed early autumnal red coloration indicative of pear decline. Of 80 comparable Bartlett trees on P. communis rootstock none died, and 8 showed varying stages of decline.

Yellow-vein Virus. Spurs of virus-free pears grew better on healthy than on vein-yellows-virus infected Bartlett trees and reaffirming the report that vein-yellows retards the growth of pear trees. Budwood of apparently healthy Bartlett trees from Beltsville and Australia carried mild strains of yellow-vein, whereas budwood from England did not.

In Utah, pears commonly carry vein-yellows-virus and a limited amount of stony pit has been observed. A virus-like disorder has been observed on Bartlett, Anjou, and Bosc pear trees in Utah and Cache counties, the symptoms of which are ring mottle leaf patterns with considerable coloration and earlier leaf fall.

3. Peach. Root and Crown Rot. Loss of peach trees in the Southern states due to root and crown rot were considerably less than in 1960. However, the Chilton County, Alabama area showed greater losses than the previous year. Three fungal species, Pythium ultimum, P. irregulare, and P. megalacanthum (phytophthora stellata), isolated from diseased peach roots were found to be pathogenic at 63°-68°F. soil temperatures. These

fungi first attack newly-formed secondary roots and the crown rot phase of the disease probably develops only when suitable environmental conditions for the pathogens exist for an extended period.

Bacterial Canker. Bacterial canker in all southeastern peach areas was nearly as severe as in 1960. The presence of the disease in newly-planted and 1-year old trees suggested the possibility that it can be spread in propagation buds. The disease, as it occurs in the orchard, has not been reproduced experimentally. The causal organism has not been identified but is presumed to be Pseudomonas syringae or a closely-related bacterium.

Wood Decay. During a survey of fungi associated with wood decay of living peach trees, sporophores of similar microscopic characters but with wide variations in gross morphology were found associated with a very common, brown, heart rot of limbs and trunks. The fungus was identified as Polyporus palustris Berk. and Curt. Peach is a new host for the fungus, the first hardwood species so reported.

Bacterial Leaf-Spot. Preliminary tests at Beltsville demonstrated peach bacterial leaf spot can be controlled with sprays of Xanthomonas pruni bacteriophage in the greenhouse but tests to determine efficacy in the orchard are not complete.

X-Disease. In some Utah peach orchards the natural spread of X-disease was more rapid in 1961 than in 1960 and the most common virus strains were mild to moderate in severity with symptoms developing late in August and September. In Riverside County, California, X-disease infected peach trees were found in two orchard locations for the first time. In the principal peach and cherry growing districts of Washington east of the Cascade Mountains the occurrence of X-disease infected peach and cherry trees serious 10 years ago is now uncommon and the disease is no longer of economic importance.

Peach Mosaic. The annual survey of peach orchards within the quarantine area of southern California resulted in the detection and removal of 343 trees (0.20 percent) infected with the peach mosaic virus. A complete survey of peach trees in Washington County, Utah, resulted in finding 34 infected trees, mostly located in 2 adjacent orchards in one area. Native plums are suspected of being the source of the peach mosaic virus in this new outbreak.

One strain of peach mosaic virus, regarded as a latent in apricot varieties commercially grown in southern California, produced foliage symptoms on 62 to 100 apricot varieties grown as test trees in experimental plots; another strain of the virus induced fruit symptoms on 22 of the test varieties employed.

Peach Rosette. At Fort Valley, Marianna plum, reputedly immune to peach rosette virus, was top-worked on peach and inoculated with peach rosette from two sources. In one group of inoculated trees, typical symptoms of peach rosette developed; in the other, the inoculated trees showed distress and proved to be carriers to peach rosette virus. It is also evident that certain isolates of peach rosette virus produce symptoms on Marianna plum grown from cuttings.

Certain P. injucunda trees inoculated with peach rosette virus developed characteristic symptoms and died within a few months, whereas others expressed symptoms of distress and remained alive, and good sources of the virus, for as much as five years. A study was initiated to determine whether the difference in reaction of trees of the same species to peach rosette virus is due to genetic differences or to strains of the virus.

Phony Peach. At Fort Valley, Georgia, a study of the spread of phony disease in peach orchards indicated a pattern similar to the wind dispersion of dust or corn pollen but with a more rapid regression rate.

4. Plum. Plum Rusty Blotch. In California, natural spread of this recently described virus disease of Japanese-type plums was charted in 2 Kern County orchards and spread was found to be very slow.

5. Cherry. X-Disease. A survey of cherry orchards in Utah County, Utah, for X-disease showed fewer diseased trees on Mazzard rootstock than in earlier surveys; a considerable increase in wilting, declining, and dead cherry trees on Mahaleb rootstocks was found but was attributed partially to factors other than X-disease. Natural spread continued to be rapid within orchards where diseased trees remained as an inoculum source. Some degree of resistance or tolerance to infection by X-disease virus was shown by the cherry varieties: Black Tartarian, Dickie Braune Blinkenberger, Burbank, Deacon, Lyons, Cardofer Fruhe, and Long Stem Bing.

Necrotic Rusty Mottle. In southern California sweet cherry trees infected with the virus have been found for the first time in orchards located in Riverside and Los Angeles counties.

In Utah, host range studies have shown the Seneca sweet cherry variety more susceptible than Lambert or Sam to a severe strain of the virus on field test trees but equivalent to Lambert and less susceptible than Sam in greenhouse tests. Field tests on other sweet cherry varieties indicated that Deacon, Macmar, Napoleon and Long Stem Bing developed mild symptoms; Cardofer Fruhe showed no symptoms until late in the season; and Burbank, Lyons, and Dicke Braune Blinkenberger remained symptomless when inoculated with a severe strain of the virus. The Black Tartarian variety has long been judged as a symptomless carrier of necrotic rusty mottle virus. In Washington, trees of the following species and varieties were found to be immune; seedlings of

Prunus tomentosa, P. virginiana, and P. besseyi; budded trees of Italian prune, Ne Plus Ultra almond, and Elberta peach; and a provincial domestica plum called "German plum." Montmorency sour cherry was demonstrated to be partially resistant to the virus.

Little Cherry. Two clones of Kwanzan and one of Shiro-fugen flowering cherries, used generally as index varieties for several stone-fruit viruses, have been found free of all known stone-fruit viruses and particularly little-cherry virus.

Four additional flowering cherry varieties have been discovered which preliminary tests indicate are equivalent to or better than the variety Kwanzan as an index test plant; 3 of which tested negative for little cherry virus and one (Gyoiko) tested negative for all viruses by the standard indexing methods employed.

Rugose Mosaic. In Washington County, Utah, rugose mosaic virus was transmitted from a number of sweet cherry trees, many of which were rapidly declining. An unusual foliage symptom in the nature of narrow, thickened, strap-shaped leaves along with the usual rugose mosaic symptoms, developed on 2 experimental Bing cherry trees which had received inoculum 4 years previously from a rugose mosaic source. The cause of this unusual symptom is not yet understood although a previously unrecognized contaminant virus may be involved.

Unknown Disorder on Van Sweet Cherry. Two Van cherry trees growing in field plots at the North Ogden Horticultural Station, Utah, produced malformed fruits with a very bumpy rough condition. In 1957 and 1958 these trees had received buds from sweet cherries imported from Iran and it is suspected that the inserted buds carried a virus responsible for the malformation of the Van fruits. Tests are in progress to determine whether a virus is responsible for this disorder.

6. Apricot. Apricot Ring Pox. In field plots at Riverside, California, an isolate of ring pox virus produced a wide variation in leaf and fruit symptoms on 103 apricot varieties tested.

7. General. Prunus Ring Spot. At Riverside, California, studies with some sources of the ring spot virus complex showed that infected peach trees will be stunted, rosetted, and reduced in growth when the prune dwarf portion of the complex is present in the inoculum employed, that intermediate growth reduction can be associated with the sour cherry yellows factor, and that slight growth reduction occurs when only the ring spot moiety is present. When 82 apricot varieties were inoculated with a severe strain of the ring spot virus complex that carried prune dwarf and sour cherry yellows factors, 68 varieties showed a varied and diverse range of leaf, fruit, bark, and growth symptoms the first year of infection.

The herbaceous host range of ring spot virus was extended by 13 new susceptibles and prune dwarf virus by 12 new susceptibles. Both viruses have a similar effect on eight of the new host species, but differ in their reaction on five species.

In Washington Alfalfa mosaic virus strains have been recovered from sweet cherry, Shiro plum, Myro plum, rose and apple. A number of these strains have been inoculated mechanically to Mahaleb cherry. Most, but not all, of the alfalfa mosaic strains inoculated to Mahaleb cause a necrotic reaction in Shiro-fugen flowering cherry.

Alfalfa mosaic strains have been consistently isolated from plum line pattern sources and apple mosaic sources. Mechanical transmission of these strains and a standard alfalfa mosaic strain to apple or plum have not been demonstrated. Graft transmissions from successful mechanically inoculated Mahaleb cherry have been made and the results of these tests will develop in this growing season.

The methods for preserving infected foliage of herbaceous plants infected with prune dwarf virus, ring spot virus, and other viruses isolated from stone fruits have been completed. Stone fruit ring spot virus has been viable for six years.

C. Varietal evaluation

1. Peach. At Fort Valley, 166 varieties and selections were tested for, chilling requirements of leaf and flower buds as well as the relative time of bloom in the field.

Promising new peach varieties at Fresno are Earliglo and Goldenred; whereas the new Richhaven, Late Gold, and Goldgem were unsuited for California. The Clinton nectarine was more attractive than Lagrand or Redgrand.

A limited planting of non-melting clingstone varieties was established at Prosser for evaluation.

At Beltsville the new variety Marcus was outstanding for the ripening season before Mayflower; and Earlired, introduced by the Department in 1960, was the outstanding variety ripening between Mayflower and Cardinal. Other superior varieties in ripening order are Sunhaven, Redhaven, Redglobe, Loring, M. A. Blake, Redskin, and Jefferson.

D. Culture

1. Apple. Results of eight years of leaf analysis from 150 central Washington orchards show that the potassium level has fluctuated moderately with no consistent trend whereas, the nitrogen level during the past 3 years has declined significantly. Magnesium deficiency on Winesap apples

was found to be widespread throughout central Washington and field plots and pot culture experiments are being initiated in 1962.

"No pruning" for 4 years doubled the yields of 7-year old Delicious apple trees; light pruning and scoring markedly increased yields; and nitrogen applications were relatively ineffective.

Herbicide studies at Wenatchee showed two new chemicals (Casoron 2,6-dichlorobenzonitrite) and EPTC (Eptam)) to adequately control weeds without being phytotoxic to fruit trees.

Watercore studies of Winesap apple fruits at Wenatchee showed that watercore increased with advancing maturity. Non-reducing sugars were positively, and reducing sugars negatively, correlated with the occurrence of watercore.

Rootstocks at Wenatchee, Washington further evaluation of EM II rootstocks indicated that this stock is not sufficiently dwarfing on Golden Delicious, Delicious, and Winesap to justify its use as a size-controlling rootstock.

Six hardy apple varieties budded onto seedling rootstocks of 4 hardy crab apple varieties were field planted but drought conditions during the summer prevented satisfactory growth. Four hardy apple varieties with an 8 to 10 inch interstock of Prairie Gold crab on Columbia crab seedlings were field planted along with standard trees to determine if the interstock will have a dwarfing effect on the scion variety.

Fruit thinning. The insecticide Sevin was tested at Beltsville and Wenatchee for reported fruit-thinning effects. At Beltsville, Sevin at 1.5 lbs. per hundred gallons of water did not thin fruits of lightly-set York and Delicious or heavily-set Stayman; whereas it did thin fruits of Golden Delicious but not to the same degree as the recommended NAA thinning sprays in the East. In Wenatchee tests, the degree of thinning with Sevin was generally greater than that of the standard concentrations of the thinning chemical Elgetol, Amide, or NAA recommended for the West; and the degree of thinning increased with increasing concentrations from .5 to 1.5 lbs. of Sevin per one-hundred gallons of water. Fruit abscission after spray application of Sevin occurred within 18 to 21 days in 1960 and 7 to 10 days in 1961 when temperatures following spray application were warmer. Sevin was not translocated from treated to non-treated adjacent spurs. The addition of a surfactant enhanced the thinning action of Sevin. Seed abortion of Delicious apples increased gradually during a period of 25 to 90 days following spray application but the growth rate of persisting fruit was not affected. In tests with NAA, Elgetol, Amide, and Sevin, fruit size at harvest and the amount of "recovery" bloom were related to the degree of thinning and not to the thinning chemical used.

Fruit bud formation. When the foliage of Golden Delicious trees at Wenatchee was drastically reduced, 2 leaves per spur, in "off years," NAA sprayed limbs did not form any more flowers than similar limbs not sprayed. At Beltsville, the growth rate of persisting fruit was temporarily suppressed by NAA sprays.

In photoperiod-growth regulator studies with Jonathan, short days were most favorable for total growth and long days favorable for flowering. Flowers failed to form on trees in long days with supplemental fluorescent light unless TIBA or NAA sprays were applied. NAA and TIBA approximately doubled the number of trees to flower regardless of photoperiod.

2. Peach. The winter temperatures at Fresno were colder than normal and the chilling requirements of most peach and nectarine varieties were satisfied by mid-January. Loss of immature buds, the characteristic "bud drop" for which the cause is unknown, was the lowest amount in eight years.

Soil fumigation before replanting continued to aid growth of young peach trees in replanting tests at Fort Valley, Georgia, and Brownwood, Texas.

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SMALL FRUIT CULTURE, BREEDING AND
GENETICS, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. New improved varieties of small fruits and grapes are needed that have broad regional adaptation suitable for modern commercial use. Needs include large (for ease of picking), firm-fruited (for best handling), disease-resistant varieties for freezing and for long distance or local marketing, with a sequence of ripening throughout the season. Determination of causal agents of new diseases is needed, and methods should be developed for effective and economical control of important fungus, nematode, and virus diseases of berries and grapes, with emphasis on identification and control of viruses in strawberries, raspberries, and grapes. The testing and critical evaluation of varieties for yield and important horticultural characters, such as fruit size, firmness, color, and quality, are needed in relation to regional adaptation. Also needed are improved cultural practices in propagation and plantation management that will result in high production of good quality fruit and reduced production costs. This entails new information on environmental factors limiting production and on inter-relationships of temperatures, soil moisture, diseases, and nutrition on plant growth, hardiness, and productivity.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, and horticulturists engaged in both basic studies and the application of known scientific principles to the solution of growers problems. European bunch-grape breeding, disease, varietal evaluation, and cultural research at Fresno, California, is cooperative with the Fresno State College. Strawberry breeding research at Salisbury, Maryland; Willard, North Carolina; and Corvallis, Oregon, is cooperative with the respective State Experiment Stations; and in addition, strawberry breeding and cultural work at Carbondale, Illinois, is cooperative with Southern Illinois University. Raspberry and blackberry breeding research at Corvallis, Oregon, and Carbondale, Illinois is cooperative with the Oregon Agricultural Experiment Station and Southern Illinois University respectively. Blackberry cultural research at Corvallis, Oregon, is cooperative with the Oregon State Agricultural Experiment Station. Blueberry breeding research at Gainesville, Florida; Tifton, Georgia; Jonesboro, Maine; and Ivanhoe, North Carolina; and breeding and disease research at Hammonton, New Jersey, is cooperative with the respective State Experiment Stations. Cranberry breeding research at New Brunswick, New Jersey and East Wareham, Massachusetts; and disease research at New Brunswick, New Jersey, is cooperative with the respective State Experiment Stations. Grape

and raspberry breeding research cooperative with the North Carolina Agricultural Experiment Station was terminated in 1961. Breeding research (strawberries and raspberries) is done at the USDA Horticultural Field Station, Cheyenne, Wyoming. Breeding, disease, varietal evaluation, and cultural research with Eastern bunch grape, and breeding research with muscadine grape, is carried on at the USDA Horticultural Field Station, Meridian, Mississippi. At Beltsville, Maryland, breeding, variety evaluation, and disease research is done with Eastern bunch grape, strawberry, blackberry, and blueberry; and cultural studies are done with the Eastern bunch grape, blueberries, blackberries, and strawberries.

The Federal scientific effort devoted to research in this area totals 13.2 professional man-years. Of this number 5.5 is devoted to breeding; 4.5 to diseases; 2.0 to variety evaluation; 1.0 to culture; and 0.2 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 59.9 professional man-years divided among subheadings as follows: Breeding and genetics 26.9, diseases 10.0, and culture 23.0. Many State Experiment Stations throughout the United States are conducting strawberry research including genetics and breeding for improved fruit quality, disease resistance, and climatic adaptability; disease research about the epidemiology and control of diseases such as red stele, gray mold, root-rots, leaf-spots, and viruses; evaluation of varieties for local needs and requirements, and a wide variety of cultural studies involving problems such as tillage, fertilization, and irrigation. Grape research projects are directly related to the species grown in the particular area. In California, the European grape (Vitis vinifera) is the subject of studies on breeding and variety trials of wine, raisin, and table types and their culture. In the north-eastern United States breeding, disease, and cultural studies are underway at three stations (Illinois, New York State and Virginia) to improve the Eastern grape (Vitis labrusca). In the southeast, attention is being directed toward the culture and breeding of the muscadine grape (Vitis rotundifolia) and hybrids with the other two major types. In all cases, tests of varieties and types are important adjuncts to the breeding programs. The bramble-fruits such as raspberries, blackberries and dewberries are popular among home gardeners and are important commercial crops in several areas of the United States. Many states carry on research programs involving breeding for fruit quality, disease resistance and hardiness; epidemiology and control of diseases; provincial variety trials; and cultural practices. With the bush-fruit blueberry, plant scientists at certain of the State Experimental Stations are studying various phases of breeding and genetic, disease, and cultural research. Research in Massachusetts and Maine is primarily concerned with improving the lowbush blueberry native to New England; whereas breeding, disease, and cultural research in New Jersey, North

Carolina, and Michigan is concerned with continually improving the highbush blueberry. The cranberry is a specialized crop grown commercially in only a few states. Breeding of this crop for improved varieties and types is concentrated at the Massachusetts and Washington stations. Only three states (New Jersey, Massachusetts, and Washington) are conducting disease control and cultural studies with cranberries.

The role of nematodes in disease spread and the part these organisms play in combination with microorganisms in causing diseases is under investigation. Extensive experiments are in progress on kinds, method and rates of application of fumigants to soil for the control of nematodes. Taxonomy, host range, and effect of nutrients on nematode populations are under study in regional project NE 34, Biology of plant parasitic- and soil-inhabiting nematodes. Much of the research on diseases of small fruit is cooperative with the Department.

Industry and other organizations including private growers conduct, or cooperate in, small-fruit research. Several provincial groups are breeding and testing the various small fruits, notably grape and strawberry, for adaptability to localized areas or producers. Several chemical companies, in addition to their own testing programs, provide material for research on soil fumigation, chemical weed control, disease control, and mineral nutrition. Private growers cooperate with industry, state, and federal testing programs by furnishing land, facilities, and maintenance for the evaluation of the objectives of the programs.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. American bunch grape. American bunch grape breeding was continued without change of objectives at Meridian, Mississippi and Beltsville, Maryland. At Meridian, 3 promising selections are under extensive tests and these were originated through use of several southern species. They have excellent vigor and are productive of fruit equal to or superior to Champanel in quality.

At Beltsville of 3336 seedlings from 13 progenies that were screened for black rot resistance, 1096 were saved as resistant and planted in the nursery. When 7 varieties reported as resistant were screened for black rot in the greenhouse only Muench and SB 12-375 were considered highly resistant. One non-black rot resistant advanced test selection US 4801-38, appeared very outstanding in 1961. This selection has many characters of V. vinifera. A total of 32 new selections were made from a seedling field for further evaluation. Many of these are seedless. Approximately 2,250 seeds from 5 crosses for

black rot resistance were planted in flats for screening. Also 3,200 of 4 crosses not having black rot resistance were planted.

2. Muscadine grape. Further work on hybridization of grapes by muscadines indicate that fertile seedlings can be obtained on the diploid or tetraploid level by crossing the species hybrids to either bunch grapes or muscadines. Colchicine treatments have yielded tetraploid of Black Monukka, Perlette, Thompson Seedless and Exotic. These are now available for use in breeding work.

Emphasis is on origination of perfect flowered high quality varieties. At Raleigh, North Carolina 5 perfect flowered varieties ripening from early to late mid-season were introduced. All of these are sweet, highly flavored varieties that are adapted from about Richmond, Virginia southward. At Meridian the following North Carolina material was established for further use and evaluation; 13 muscadine selections, 58 muscadine bunch grape F_1 hybrids, and 136 seedlings of muscadine bunch grape hybrids. This last group was the result of back crossing the F_1 to a muscadine parent. 2,200 unselected diploid seedlings were placed with cooperators to be grown and evaluated. Six additional $1/4$ acre plantings were made with growers to test 6 selections. 1,450 tetraploid seeds were obtained from 5 seed parents.

3. European bunch grape. Vinifera grape breeding at Fresno, California continued to emphasize origination of seedless table grapes and rootstocks resistant to nematodes and Phylloxera. Cross pollination yielded 5,090 hybrid seeds and an additional 1,130 seeds were obtained from self-pollinated flowers. Approximately 4,300 grape seedlings from the 1,960 seeds were set out in test blocks for fruiting. Of 8 selections now on commercial trial 4 are White Seedless, 2 are black-seeded, 1 is red-seeded and 1 is white-seeded. The most promising selections are an early ripening black-seeded selection of high quality; a very firm red-seeded mid-season selection; and a very early ripening white-seedless selection. Nine grape seedlings that fruited for the first time last year were propagated for second tests, all are seedless types.

Seven additional commercial trials of 4 nematode-resistant rootstock selections were established including one in Arizona and one in the Coachella Valley of California where root troubles are particularly serious. Three of the tests have Emperor, and 4 have Thompson Seedless as the scion varieties. Only 49 of the original 1,155 root-stock seedlings planted in 1957 remain.

4. Strawberry. Studies continue to emphasize inheritance of resistance to red stele root rot and foliage diseases. At Willard, North Carolina, 10 seedlings, representing 4500 initially tested seedlings of 15 progenies, have been selected for advanced testing as adaptable for southeastern United States. In addition, 57 new

selections were propagated for row tests and 24 seedlings from an interspecific hybrid with South American F. chiloensis x Albritton were retained for further work. A 3-year study of the effects of seed age and degree of inbreeding on subsequent germination was completed and the data is being analyzed for publication. 5,770 new seedlings were set in the field that will fruit in the spring of 1962. In Maryland, 10 seedlings have been selected, from more than 300 being tested currently, for resistance to one or more races of red stele disease. Of 8,900 seedlings planted in 1960, 143 were selected for further test. Of 26,000 seedlings screened during the winter of 1960-61, 4,780 were selected as red-stele resistant and these will fruit in 1962. During the winter of 1961-62, 27,900 seedlings were similarly screened. A detailed inheritance study dealing with red-stele races A-1 through A-5 revealed that the percent of resistant seedlings depended upon the resistance of the parents and the particular race of red stele involved. A report has been published on the study. The Yaquina clone of F. chiloensis has transmitted high red stele resistance to seedlings whereas Nelscott and Del Norte have not transmitted resistance against race A-5. Surecrop has not transmitted the degree of resistance to race A-3 as has Stelemaster or some of the other red stele resistant selections. When all roots were cut from resistant seedlings that had been removed from red-stele infested soil and propagated under intermittent mist, the plants were found to be completely free of red stele. All seedlings saved from the screening test with race A-5 are now being propagated in this manner. Over 1,100 seedlings from seed of Surecrop x Stelemaster, irradiated to potentially induce mutations resistant to red stele race A-5, were planted in the field for fruiting tests in spring of 1962.

At Carbondale, 105 selections were made from about 10,000 seedlings planted in 1960, and propagated for further testing. During 1961 another 6,000 seedlings were planted in the spring, rated for foliage diseases in the fall, and will be fruited in the spring of 1962. Three Md-US selections, numbers 2593, 2601 and 2700, were very good in advanced tests.

At Corvallis, Oregon, 13 new selections, made in 1961, having F. chiloensis as the immediate parent were highly resistant to red stele and some were tolerant of viruses. Seven of the advanced selections were highly desirable in frozen-pack tests. In addition, 9600 seedlings are being screened for red stele resistance. Hail damage negated the breeding for winter-hardiness program at Cheyenne, Wyoming during 1961. A high quality, red stele resistant, virus tolerant, large and firm-fruited selection was named Molalla and released to growers for spring 1962 planting.

5. Raspberry. Raspberry breeding was discontinued at Raleigh, North Carolina, but continues at Corvallis, Oregon and was expanded at Carbondale, Illinois, and Cheyenne, Wyoming. The Carbondale research hybridized Asiatic and American black- and red-fruited species to originate disease-resistant and winter-hardy varieties; whereas the Corvallis studies originated large firm-fruited varieties for commercial canning and freezing. At Carbondale, the varietal and species germ-plasm source collection was expanded and evaluation of 1,200 seedlings, planted in 1960, was started. Some fall-fruited seedlings show commercial promise. At Corvallis, survival of red raspberry seedlings planted in 1960 on very heavy soils was poor. In 1961, 37 seedlings were newly selected for further testing. Several of the earlier selections were particularly promising for freezing and canning and one was named Fairview and will be available for 1962 spring planting. Breeding of winter-hardy raspberries continues at Cheyenne, although all plants currently there have been winter-killed.

6. Blackberry. Breeding work was discontinued at Beltsville, Maryland, and Raleigh, North Carolina, but continues at Corvallis, Oregon, and Carbondale, Illinois, to originate thornless, winter-hardy, and disease resistant varieties. At Carbondale, a germ-plasm collection of blackberry varieties and selections was planted; and about 4,000 seedlings planted for field tests. At Beltsville, evaluation of previously hybridized seedlings continued and some selections were made for winter hardiness. None of the thornless selections were fully hardy during a severe 1961 winter and none were as hardy as Darrow and Eldorado varieties. At Corvallis, where emphasis is on varieties for commercial processing, an early, large-fruited variety for freeze-processing has been named Aurora. Other promising selections are being propagated for further testing. The Williams blackberry, a mid-season, disease-resistant variety adapted to the southeastern United States, resulted from the North Carolina breeding studies.

7. Blueberry. In Florida the aim is to originate varieties with low chilling requirements through use of native species in breeding. A total of 20 seedlings of complex origin appear sufficiently promising for preliminary propagation. Some of these ripened 3 weeks earlier than Woodard and were of equal or better quality. Approximately 7,000 seedlings were obtained from 1960 crosses and an equal number from 1961 crosses. These seedlings have resulted from hybridization of the most promising Florida low-chilling selections with large-fruited highbush selections from the North. Attempts were made to hybridize the rabbiteye and artificial tetraploid selections but poor fruit set was obtained.

In Georgia, the emphasis is origination of large-fruited, high quality, early-ripening rabbiteye types, and 8 rabbiteye selections were outstanding in 1961. All selections are very productive and 2 of them are 10 days to 2 weeks earlier than any previous selections. About 2,500 seedlings are ready to be set in the field for fruiting tests.

Emphasis in North Carolina is on combining superior horticultural characters with resistance to the cane canker disease. The most promising selections were propagated and established in several locations in the state for more extensive testing, particularly for resistance to cane canker. Two selections, NC 678 and NC 683, were very outstanding in 1961 and appear to have variety potential. Preliminary attempts were made to develop a greenhouse inoculation technique for screening young seedlings against cane canker. About 1,000 seedlings are ready to go to the field for fruiting tests.

After a very severe test winter in New Jersey in 1960-61, 41 new selections were made from 8,000 seedlings on first test. Eleven selections from previous years were considered outstanding and have been propagated extensively for distribution to test sites in other states.

A powdery mildew epiphytotic occurred in the field in New Jersey in the fall of 1961. Several seedling progenies were scored for resistance including a progeny of 11-93 x Ashworth that had been previously divided into two groups on the basis of susceptibility as young seedlings in the greenhouse benches. The seedlings classified as susceptible in the greenhouse were most susceptible in the field. Susceptibility appeared to be transmitted as a partially dominant character. Ashworth, Herbert, and F-72 appeared to transmit susceptibility to a large number of their seedlings, whereas seedlings resulting from crosses of 11-93, E-3, and Coville were more resistant than most progenies. Progenies with highest resistance occurred where both parents were resistant.

Major objectives for the North include the development of consistently productive, cold hardy types having large fruit size, high quality, and small dry scars for better shelf life. In Massachusetts, a combination of hurricane damage in the fall of 1960 followed by severe winter temperatures reduced the crop of most selections and varieties to zero. A total of 10 selections had acceptable crops and will be tested extensively. In Maine, 28 new winter-hardy selections were made having Mich 1914, Me 5003, Me 3205, Sebatis, and Me 2822 as sources of hardiness. The most productive seedlings occurred in crosses with Sebatis parentage, a hardy highbush selection from New Hampshire. Two selections from a progeny of Me 3205 x Earliblue, were notable for their extreme earliness and are being used as parents for this characteristic. In Michigan, a total of 13 new

selections were made from the seedling field. Eleven previous selections appeared outstanding and are being extensively propagated for widespread testing. Two of these, the E-55 and E-66, looked especially promising because of their uniform large size and productive plants.

At Beltsville, approximately 65,000 seeds were harvested from 21 crosses. A total of 15,300 seedlings from the 1960 crosses were grown in the greenhouse and distributed to seedling growers for fruiting tests.

8. Cranberry. No new cranberry breeding has been started but final evaluation of 14 selections continues. Three new varieties were introduced in cooperation with the Massachusetts Agricultural Experiment Station. These are Bergman, Franklin and Pilgrim. All 3 appear resistant to false blossom, virus and they ripen from early to late with Franklin early, Bergman midseason and Pilgrim late.

B. Diseases

1. Grape. The major problems continued to be the detection of viruses by different means, determination of the effect of the single virus complexes on grapes to search out virus-free clones and determine whether virus-free stocks can be maintained in a virus-free condition. Most of the work is being done in California with a very limited project at Beltsville. The Beltsville work consisted of a collection of 70 kinds assembled for indexing. Techniques for mechanical transmission of yellow vein virus have been refined. At Davis, vein-banding was recognized as a virus distinct from fan leaf, yellow mosaic, and yellow vein but these diseases may be caused by different strains of same virus. Strains of leaf-roll virus showing varying degrees of symptom severity, and varietal sensitivities to these strains, are apparent. Application of potassium and magnesium in a commercial vineyard improved yield and fruit quality of healthy, but not the leaf-roll infected, vines.

Powdery mildew was much more severe on healthy vines than on leaf-roll infected vines of several varieties. Varietal differences were much more pronounced with healthy vines than with the leaf-roll infected vines. Varieties having a high osmotic concentration of the cell sap tended to be resistant to powdery mildew.

In a comparison of indexing methods soil-borne viruses were transmitted more readily when dormant buds were grafted onto dormant indicator vines than when dormant buds were grafted onto actively growing indicator vines. However, leaf-roll transmission was considerably better when the dormant bud was grafted onto an actively growing indicator.

Soil fumigation with methyl bromide and carbon bisulphide indicated some control of soil-borne viruses. Roots of infected vines, to be destroyed, were killed more effectively with 2,4-D amine foliar spray than by a trunk-painting application; and the spray was more effective applied in fall than in mid-summer.

In the continued search for virus-free stocks 2 plantings were discovered that had been propagated about 1905. Most of the vines appeared virus-free and are being indexed as sources of virus-free material. Indexing of 187 varieties introduced from foreign countries during the 1951-1961 period, revealed 51 that had virus diseases, all of which were already recognized in California vineyards. To obtain virus-free plants, excised-tissue culture and high-temperature virus-inactivation experiments were done with limited success.

A new foundation block of varieties free of all known viruses has been established on campus at Davis which includes three root stocks, 12 table and raisin varieties and 33 wine varieties.

2. Strawberry. At Beltsville, Md., the pathogenicity of single zoospore isolates of all 6 U. S. races of Phytophthora fragariae, the red stele fungus, has been determined to be the same as those for comparable mass-transfer isolates from which they were derived. Germination of undifferentiated oogonia was observed by dung infusion. Pouring inoculum into 1 inch deep furrows in beds of established seedlings under cool temperature conditions in the greenhouse was a satisfactory procedure for inoculating large soil benches of strawberry seedlings with the red stele fungus. Of 4 soil fumigants tested for red stele control in Beltsville, methyl bromide and trizone gave the best results but did not eradicate the fungus. No practical method for eradication of red stele is known. Work continued at Beltsville, Md. and Corvallis, Oreg. to study the effect of virus complexes on behavior of different varieties and selections, the symptom expressions of viruses in different indicators and attempts to inactivate the viruses. A search for a clean stock of desired varieties continued. In Oregon, tolerance tests of selections with a severe yellow virus complex indicated that several of the recent selections are highly tolerant. In a test of the virus tolerance of 25 different clones of F. chiloensis 18 were found highly tolerant but none were found immune.

Excision of growing points and rooting them aseptically was partially successful as a technique to rid infected plants of certain viruses. Plants of Marshall, Siletz, Shasta, Columbia, Cascade, Molalla, Puget Beauty, and about 130 selections have been indexed free of all viruses. Crinkle and yellow edge viruses were found in roots, whereas vein banding, mottle and latent C viruses could not be demonstrated in the roots of infected plants.

Work at Beltsville on eradication of latent A virus from standard varieties by heat and excised axillary buds was successful in 6 of 10 varieties treated and the virus-free plants have been propagated for distribution as superior stocks. Leaf-graft studies using known virus sources showed that summer grafting was markedly less efficient to transmit latent A and C viruses. When combined with crinkle virus, latent-virus A appeared sooner, and virus C later in summer than in winter.

Indexing of commercial stocks from 3 cooperating nurseries revealed the presence of mottle virus. Lack of isolation and failure to replace stocks periodically appear to be the reasons for a relatively large amount of virus detected.

A variegated-foliage disorder was nearly universal in the variety Dixieland stocks as well as in 9 of the most promising selections at Willard, N. C.

A technique was devised for mass production of spores of Botrytis cinerea that can be used for comparison of susceptibility of varieties and selections.

3. Raspberry and Blackberry. Rubus henryi, when leaf-grafted, was a reliable and rapid indicator plant for raspberry viruses. Raspberry mosaic virus and its components, when inoculated singly and in all combinations in black raspberry, produced symptoms which were in general no more severe than those of the heat-labile component alone.

Two heat treated clones of Latham red raspberry were found to be virus-free and are being increased for distribution. Stocks of 11 red raspberries and 4 black raspberries have now been propagated under virus-free conditions and are being distributed to experiment stations and state departments of agriculture.

In the first year of a test of infected versus virus-free plants of Durham and Newburgh red raspberries at Beltsville, the virus-free plants produced many more fruiting canes and much greater fruit yields. A biweekly parathion application from bud-break to leaf fall effectively controlled the major mosaic vector aphid, Amphorophora rubi and the spread of raspberry mosaic viruses. During a two year study at Beltsville, A. rubi reached a major population peak in July and a minor one in September. September red raspberry is an excellent host for A. rubi but the aphids are unable to transmit raspberry mosaic to healthy September plants; but they could transmit mosaic virus from graft-infected September plants to black raspberry indicator seedlings. The existence of two strains of raspberry-curl virus was reconfirmed and blackberry was found to be another host of the beta strain. Plum Farmer black

raspberry was immune to the beta strain.

4. Blueberry. A varietal difference in persistence of the virus disease, necrotic ringspot, within the host plant was found; inoculated plants of Burlington, Collins, and Weymouth readily transmitted the disease to indicator plants, whereas plants of Berkeley, Bluecrop, Blueray, Coville, Herbert, Jersey, and Rancocas did not. Tests indicated that the necrotic ringspot virus is closely related to the type strain of tobacco ringspot rather than to the previously reported tomato ringspot. Early and midseason applications of Captan reduced fruit rots, though not to a commercially acceptable degree, caused by Botrytis and Gloeosporium fungi.

5. Cranberry. The degree of fruit rot in bogs could not be directly correlated with bog-temperature and bog-humidity differences. Fruit-rot control with Phaltan, tested for the first time in New Jersey under high-rot conditions, was comparable to the recommended Zineb.

C. Varietal Evaluation

1. Grape. Test plots at Beltsville, Md., Meridian, Miss., and Fresno, Calif., are being maintained. Further renovations of the test plantings at Fresno were necessary when the certification program recalled certain varieties because of newly found virus infection. No important additions or observations were made. The newly established test plots at Beltsville made satisfactory growth and should be in production next year.

D. Culture

1. Grape. Propagation studies with European bunch grape at Fresno indicated that grafting can be done anytime during the dormant season providing the grafts are kept cool, moist, and aerated; and the root-stock variety was more important to success than time of grafting or post-grafting treatment. Long-term tests at Meridian with the Eastern bunch grape varieties, Concord and Delaware, indicated that the survival of the scion varieties is related to the understock variety used.

2. Strawberry. At Beltsville, cold-stored strawberry plants set June 1 yielded as heavily as those set in early April; and the June planting eliminated the runner-plant thinning, and reduced the weed control operations (cooperative with Agricultural Marketing Service). CIPC to control weeds was not toxic to strawberry plants when applied monthly at 1/3 lb per acre during November to March. Several chemicals related to EPTAM, but nontoxic to strawberries, showed promise for summer weed control. At Carbondale, Ill., replicated blocks of several varieties were planted for post-harvest defoliation experiments.

3. Blackberry. In the seventh year of a long-term fertilizer study at Corvallis, Marion blackberry plants yielded best when receiving annual applications of nitrogen.
4. Blueberry. Fertilization of ovaries occurred more rapidly at warm, than at cool temperatures; and fertilization was sooner in cross-, than in self-pollinated flowers.

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TREE NUT CULTURE, BREEDING AND
GENETICS, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Tree nut production in the United States is much below the national consumption and needs to be materially increased. Production is limited by the need for better varieties that are more productive, disease resistant, of better quality, and less subject to spring frosts. More information is needed on nutritional requirements and the factors that induce biennial bearing. Diseases are often limiting factors and may even cause complete crop failure. Almonds are particularly subject to late frosts; later blooming varieties are feasible. Nut trees are known to have higher potassium requirements than the trees can absorb in heavy crop years. Methods of inducing increased absorption are needed. Tree nut crops have relatively low per acre production. New information is needed on tree spacing, dwarfing, rootstocks, and chemical fruit setters as well as more productive varieties to increase production per acre.

USDA PROGRAM

The Department has a continuing long-term program involving breeders, plant pathologists, soil scientists, and horticulturists engaged in both basic studies and the application of known principles to the solution of growers' problems. Almond breeding research at Fresno, California, is cooperative with the California Experiment Station. Filbert breeding and cultural research at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Pecan breeding, variety evaluation, disease control and cultural studies at Meridian is cooperative with the Mississippi Experiment Station. Disease control and orchard management at Albany, Georgia; disease control, orchard management and nutrition at Shreveport, Louisiana; variety evaluation, orchard management and breeding at Brownwood are at federally operated stations. Research on walnut diseases and culture at Corvallis, Oregon, is cooperative with the Oregon Experiment Station. Breeding research and variety evaluation (chestnuts, filberts and hicans) is carried on at Beltsville, Maryland.

The Federal scientific effort devoted to research in this area totals 12.0 professional man-years. Of this number 1.7 is devoted to breeding; 1.5 to diseases; 1.3 to variety evaluation; 7.0 to culture and 0.5 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 7.2 professional man-years divided among subheadings as follows: Breeding and genetics 3.7, diseases 1.6, and culture 1.9. Georgia, Florida, Louisiana, Mississippi, New Mexico, Oklahoma, Texas and Alabama are conducting studies on pecans including breeding and varietal evaluation, pecan scab and other diseases, biochemical and physiological factors on set, fertilization, tree spacing and cover crop management. The bulk of the filbert research at State Experiment Stations is done by the Oregon Station including work on breeding, varietal evaluation, bacterial blight control, water requirements and other nutritional and cultural factors. California carries on research on almonds including breeding, varietal evaluation, disease and insect control, water requirements and other cultural research. English walnut research is largely confined to California and Oregon where the work is mainly on breeding, disease control and on cultural factors.

Industry and other organizations including grove owners also conduct research of interest and value on tree nuts. Several chemical companies supply materials for testing in the control of diseases and for nutritional purposes on tree nuts. Grove owners cooperate with chemical and other organizations including State and Federal Experiment Stations by furnishing land, facilities and maintenance for the evaluation of hybrids, for fertilizer trials and for disease control. Estimated annual expenditures are equivalent to approximately 6 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

a. Breeding

1. Almond. At Fresno thirty one selections have been made from progeny of crosses designed to produce small flat kernels for the candy bar trade or to produce a late blooming variety which escapes spring frosts. Nine of these show characters sufficiently like Nonpareil to warrant field trials, one of which is considered by the almond industry to be an excellent substitute for Peerless or NePlus Ultra. Twenty one have the desired small flat kernels.

Progeny from inbred lines have produced more uniform kernel shape and other nut characters and more uniform date of flowering than progeny from crosses. Selfing will be continued to produce more homozygous lines in an attempt to fix certain desired characters and thus learn more about their inheritance.

Interspecific apricot-almond hybrids have set no fruit but a few seedlings have produced viable pollen which has been used in backcrosses to almond. Progenies from these will be studied for inheritance and chromosome numbers.

Studies of multiembryo nuts have shown that some of the embryos in such nuts are somatic; twins also may result from splitting of the zygote and an early stage.

Fourteen almond selections were crossed with Nemaguard (root knot resistant) peach in an attempt to combine nematode resistance with the vigor of peach-almond hybrids for use as rootstocks. Considerable variation in compatability was experienced with different almond selections. Interspecific hybrids of between almond and desert prunis species (P. andersonii and P. fremontii) have been made in an attempt to incorporate drought resistance in rootstocks for use in nonirrigated semi arid areas. Hybrids with P. subcordata were made to incorporate tolerance to wet soils. All such hybrids will be evaluated for compatability with almond varieties.

2. Filberts. Crosses were made at Beltsville, Maryland between a number of parents to study inheritance as a possible cause of blank nuts. No significant differences resulted among the progenies. A male-sterile seedling which produced 83.5 percent blanks in 1960 and 78.5 percent in 1961 is being used for genetic studies.

Selections have been made among second generation progenies in a long term study to develop more winter hardy varieties.

3. Chestnuts. Studies were continued at Beltsville, Maryland to develop more productive Chinese chestnuts with better nut quality. Progenies from two varieties were grown in isolation so that they would cross pollinate; progenies from these appear to be more uniform than open pollinated Chinese. Eight seedling selections of open-pollinated varieties have failed to equal the productiveness or quality of Nanking.

Budded trees of Nanking were irradiated with up to 5000 r. Those receiving 5000 r in 1960 produced branched staminate catkins in 1961 but failed to set leaf buds; those receiving 2500 r produced new shoots from adventitious buds just above the graft union; those receiving 1250 r produced branched catkins and large abnormal leaves indicating possible genetic changes.

4. Walnuts. At Beltsville second generation seedling of J. nigra x regia showed wide variation, some of which although hybrids tend to resemble their parents. As such they can be backcrossed to gain the original quality of the parent but may have picked up some of the desirable characters of winter hardiness, disease resistance, etc.

5. Pecans. The pecan industry needs new pecan varieties which are more consistently productive, have better kernel quality, are disease resistant and are adapt to commercial shelling. At Brownwood, Texas a breeding program has been underway for 30 years; over 8000 hybrids have been fruited and 5 have been named and released. Over 1700 hybrids were fruited in 1961, approximately one half for the first time. Progeny performance has established certain varieties and selections as good parents to transmit the characters desired. Approximately 560 controlled crosses were made in 1962 and should be fruiting by 1966. Several advance selections are now fruiting in several locations and it is expected to name and release at least two of these.

Work with hicans (pecan x hickory) now includes 46 second generation hybrids, which are being backcrossed to combine hardiness, early maturity and disease resistance of the hickory with the good quality of the pecan (No. 696 and A-93).

B. Diseases

1. Pecan scab. In Oklahoma extensive tests showed Dithane Z-78-2/100, Parzate C - 2/100 and Dodine (cyprex) 1/2/100 and 1/100 to be equal to Zineb and to give good control of scab in the orchard. (2/100 - 2 pounds per 100 gallons water). In Texas Dodine at 1/100, 1 prepollination spray followed by 5 cover sprays gave excellent scab control. Satisfactory control was also obtained with Bordeaux 4-1-100 prepollination and 6-2-100 cover sprays, Zineb (65 percent w.p.) 2/100, and Dodine 1/2/100 in descending order. In Georgia Dodine at 1/2/100 in 5 cover sprays was satisfactory under conditions of light scab, but better control resulted with 1/100 or with 1/2/100 in the first two cover sprays followed by three cover sprays at the 1/100 rate.

2. Laboratory Studies of Pecan Scab Fungus. The scab fungus Fusicladium effusum does not fruit well in culture. A method of producing spore in quantity for use in screening hybrid seedlings for resistance is badly needed. In Oklahoma studies on both agar and synthetic media were continued. Of 42 media studied the ten best in descending order are: Peptone-dextrose agar, V-8 juice agar, V-8 juice-dextrose agar, peptone-dextrose agar plus minerals and vitamins, nutrient dextrose agar, V-8 agar, casein hydrolysate-dextrin agar, Chinese chestnut agar, Chinese chestnut agar plus cocoanut milk and V-8 agar minus calcium carbonate.

A glucose-asparagin-mineral salts medium plus thiamine and biotin proved to be a satisfactory liquid medium. The optimum concentration of the mineral salts has not yet been determined. Using this medium it was

found in shaker cultures that smaller amounts of medium in larger flasks to give more surface increased the amount of growth of the fungus, - 100 ml of medium in 500 ml flasks was the optimum of the cultures tried.

3. Toxicity of Plant Oils to the Scab Fungus. Certain petroleum oils have been used to control foliage diseases of plants. Mycelial plugs of the scab fungus were immersed for 6-8 minutes in full strength and diluted plant oils and constituents. The material was then removed on sterile filter paper and the plug placed on agar and observed for growth. Full strength oils toxic to the fungus were: garlic, onion, thyme, peppermint, rose, bergamot, chrysanthemum, anise, clove, vanilla, cassia, styrax, bay, originum, geraniol, eugenol and several constituents. These materials were not toxic in dilutions of greater than 1-10, therefore, would be too expensive for potential scab fungicides.

4. Other Pecan Foliage Diseases. At Melrose, Louisiana field tests with conventional fungicides showed that brown leaf spot, liver spot and other foliage diseases could be controlled with single applications in early May. The materials used in order of effectiveness are as follows: 6-2-100 bordeaux, 2/100 Zineb (65% w.p.) Dodine 1/100 (65% w.p.).

5. Moneymaker Dieback. A peculiar disorder limited to the Moneymaker pecan variety characterized by distorted chlorotic leaves, stunted growth and dieback has been found at four locations in Georgia. Although the symptoms of the disorder suggest a virus disease, no transmission has been effected when affected scions are grafted on healthy trees and healthy scions grow normally on affected trees.

6. Control of Walnut Blight. In Oregon of 10 materials tested bordeaux mixture was the most effective, followed closely by Zinc Coposil and tribasic copper sulfate. Bordeaux reduced infection of the nuts from 14.7 to 1.9 percent but is somewhat toxic causing some leaf injury. Bordeaux applied as a concentrate spray was equally effective as when applied with an air blast sprayer.

Comparative studies of the Howe variety showed for the third consecutive year that this variety is resistant to bacterial blight; only 1.8 percent of the Howe nuts were affected as compared to 51.2 percent on neighboring trees of Franquette.

7. Walnut Blackline. Trees developed from scions of blackline-affected-Franquette topworked on J. hindsii seedlings in 1956 and 1957 are normal and have shown no signs of blackline.

8. Mushroom rootrot. Inoculation tests in the greenhouse have shown that J. hindsii is more susceptible to infection than J. regia.

9. Verticillium Wilt. All attempts to infect J. regia either by dipping bare rooted seedlings in suspensions of microsclortia of the verticillium fungus isolated from maple or by growing seedlings in microsclortia infested soil have failed, indicating that this rootstock is at least highly resistant.

10. Pecan Bunch Disease. Bunch, a serious virus disease, affecting pecan continues to spread and cause serious loss to local growers and concern to the industry. Grower reports indicate that the disease is spreading rapidly in some local areas. Bunch does not kill trees but affected trees are completely unfruitful once they are thoroughly affected. New investigations designed to develop basic information and develop control procedures has been initiated.

C. Variety Evaluation

1. Persian Walnuts. Several selections were added to the variety orchard at Corvallis, Oregon to bring the collection to 3 trees each of 23 varieties and selections.

Of 49 selections and varieties examined in the laboratory 21 had better than 50 percent kernel. Fifteen of the 21 and 9 of the top 10 were Manregian seedling selections. The top 10 ranged from 53.1 to 59.5 percent kernel and all are heavy producers.

California varieties and selections were generally poor in Oregon in 1961 but Franquette was better than normal and produced kernels of good color with very little shrivel.

At Beltsville the variety Hansen has continued to be outstanding from the standpoint of production, winterhardiness, and quality. It is being widely planted as a dooryard and utility tree.

2. Pecans. Several new varieties originated by State Experiment Stations, and private individuals have been compared with standard varieties at Meridian, Mississippi. The Blaine seedling from Darling, Mississippi, which is supposed to be a seedling of Success, produced nuts double the size of those of Success and were better filled. Peruque fruited well but the leaves developed severe scorch and the nuts were small and poorly filled.

3. Filberts. Evaluation of filbert selections in Oregon showed 17 of the 26 studied to have a higher kernel percentage than the leading commercial variety Barcelona. The kernel percentage of the selections ranged from a low of 35.9 to a high of 49.5 percent and Barcelona averaged 39.3. The two best selections were a variety named Red Wing and a selection known as Lansing Seedling.

D. Culture

1. Pecan Nutrition. At Sherard, Mississippi, 170 pounds per acre of nitrogen increased the production of nuts on large Success trees by 31 percent over addition of 100 pounds of elemental N. No increase in yield, size or quality of nuts resulted from the addition of 100 or 300 pounds of potassium per acre.

At Meridian, Mississippi, Success and Moneymaker trees were fertilized with 600 pounds of 6-8-8, 12-8-8 and 12-8-24 in split plots of sod and cultivation. The Moneymaker 12 N trees in sod outyielded the 12 N cultivated trees and the 6 N sod or cultivated trees, but the cultivated Success trees outyielded the sod trees at all fertility levels. No differences were found in nut size, percentage kernel or kernel quality.

At Monroe and Melrose, Louisiana duplicate experimental plots were established to study uptake of K from KCl. and KNO_3 fertilizers. There was no increase in yield or quality of nuts from either source of K in either location. There was some increase of K in the leaves from both K sources but this apparently did not affect yield.

At Monroe, Louisiana, in a 2 x 2 x 2 factorial fertilizer experimental plot using N, Ca, and K, N was consistently increased in the leaves and consistently increased the yield of nuts. Where nitrogen increased the N in leaves, P was decreased; potassium application increased Mg and Mn; and calcium application decreased Mn.

At Foreman, Arkansas on a Yohola loam soil in a 2 x 2 x 2 factorial experiment using N-P-K, P was increased in leaves receiving P but was reduced in leaves receiving N. However, the N plots consistently yielded more nuts over a period of years. The fertilizer applications were discontinued in 1960 but the proportionate levels of N and P continued in 1961 on the respective plots.

At Shreveport two factorial fertilizer experiments extended over the period of 1951 - 1960 with annual applications, one involving N-P-K and the other N-Ca-Mg. Yield of nuts and tree growth was increased by the addition of N but not by any of the other materials. In another experiment involving P, K, P + Zn, Mg + Mn and borax, the boron and zinc content of leaves was proportional to the amounts added but the other elements did not affect levels in the leaves.

At Albany, Georgia in studies established to determine the effects of time of application of N, no difference was found between plots receiving 15 pounds of N in December as contrasted to February. The yield of plots

receiving N was greatly increased over that receiving no N. Nitrogen application was discontinued on the December plots in 1958 so that by 1961 the December plots had received 30 pounds of N per tree and the February plots 48 pounds; even with this differential and the fact that the December plots had received no N for 3 years there was no difference in yield in 1962 or in the level of N in the leaves.

2. Pecan Kernel Oil Content and Nitrogen Fertilization. The oil content of nuts from fertilizer plots was consistently higher from the untreated checks than from trees receiving applications of nitrogen.

3. Pecan Orchard Management. At Albany, Georgia orchard management including mowed vs summer cultivation have failed to show significant differences in yield. The summer cultivation plots, however, developed high acidity, characteristic of this type of management and were limed for correction. Vetch and some other leguminous covers fail to grow when soils are too acid.

4. Nursery Trees Vs Seedlings Grafted in Place. In Louisiana an experiment was started in 1950 to determine the merits of the practice of planting seed nuts at the permanent orchard locations and grafting them in place as opposed to the use of grafted nursery trees. It is known that pecan is deep rooted, has no root hairs and hence nursery trees need more care in transplanting than most deciduous trees. In 1961 the average yield from nursery trees was 137.5 pounds of nuts per tree or 2392 pounds per acre; the average yield of trees grown from seed nuts and grafted in place was 91.2 pounds or 1587 pounds of nuts per acre. The difference in production is due to the large size of the trees grown from nursery trees. In 1961 the increased yield on the nursery tree series of 805 pounds, which were sold at 20.12 cents per pound or \$163.97 per acre, indicate that the use of grafted nursery trees pays. The costs of weeding, grafting and care of young grafts on the seed in place trees approximated the increased cost of grafted trees.

5. Nutrition of Filberts. In Oregon in a well controlled factorial experiment involving potassium and boron a striking increase in yield of nuts and decrease in the percentage of blanks was obtained with two levels of added potassium. No benefit was obtained from the addition of boron and it is concluded that Oregon soils contain sufficient boron for filberts.

Potassium applied at 4.96 and 9.96 pounds of K per tree gave an average increase of 7 pounds of nuts per tree. There was no significant difference in yield between the two rates, although the higher rates increased the size of the nuts. Analysis of the whole fruits showed the shuck to contain 7.9, shell .25 and kernel .31 percent K respectively. The high requirement of the shuck for K may account for the rather surprising response from added K. These results should enable growers to obtain increased yields and substantial monetary returns.

6. Filbert Pruning Tests. A rejuvenation pruning study in Washington County, Oregon has continued to show increases over the no pruned check. The heavily pruned plots produced 300 pounds more than the checks, and 93.5 percent of the nuts were graded large as compared to 61.0 percent for the checks. Pruned trees averaged 9 1/4 inches of terminal growth as compared to 3 3/4 for checks, and were more consistent in annual bearing. Pruning had no apparent effect on the percentage of blanks or on percentage kernel.

7. Filbert "Blank Nut" Study. No progress has been made in determining the cause of blank nuts in filberts. In 12 orchards under study, 3 had a reduction and nine an increase in blank nuts averaging 11.6 per cent as compared to 8.7 in 1960.

8. Spacing and Training of Filberts. A tree spacing and training experiment is under way in Oregon involving 15 x 15, 20 x 20 and 25 x 25 distances. The 15 x 15 spacing has made the best growth. The "stubbies", trees with a short whip, have failed to branch and sucker to form the desired vase and bush type trees desired as well as standard nursery trees.

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WEED AND NEMATODE CONTROL
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on deciduous fruits and tree nuts.

USDA PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups, and is cross commodity in nature. The total weed control program involves 64.6 professional man-years' effort. Of this total, .3 is specifically directed to weed control in deciduous fruits and tree nuts at New Brunswick, New Jersey, and Prosser, Washington. The Federal scientific effort devoted to basic and applied nematode research is 23.5 professional man-years, of which 1.5 is devoted to applied research in deciduous fruits and tree nuts at Orlando, Florida; Tifton, Georgia; and Logan, Utah.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Information on the weed and nematode research for commodities by State Experiment Stations and industry is not available. For a summary statement covering all research by these agencies on weed control, see pages 240 and 241; and on nematode control, see page 276 in the Crops Research Division report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Weed Control

1. Physiological and Ecological Studies. Little is known of the effects of continued use of herbicides on the metabolism, growth, quality, yield, and longevity of perennial fruit and nut crops. If possible crop disaster due to the continued use of herbicides is to be avoided, at some imminent or future time, information on these effects must be obtained while the condition is incipient and remediable. In accordance with the recognition of these critical needs, long-term studies on blueberries, cranberries, apples, and peaches were initiated in 1960 at New Brunswick, New Jersey. Industrial, State, and Federal weed scientists have shown much interest in these studies already and their value will increase in the future.
2. Control Studies. Cranberries -- Grasses, sedges, red root, bracken fern, and a number of woody species are highly competitive weeds in cranberries. The semi-prostrate growth habit of the crop and the broadcast method of planting prevents effective use of the usual mechanical cultivation equipment. Flooding of the bogs controls many weeds with the exception of those named above. The rapid development of effective, safe, economical herbicides is crucial in the continued production of this crop. Many herbicides have been evaluated in greenhouse and field studies on cranberries at New Brunswick, New Jersey, in an intensive effort to meet these critical needs. Outstanding among recent accomplishments in this program is the discovery of an effective herbicide, 2,6-dichlorbenzonitrile, for bracken fern, one of the most serious weed problems in cranberries. This is considered a major breakthrough in the control of weeds in this crop.

Grapes -- Many mechanical devices, including the grape hoe, have been used without substantial success for controlling weeds under the arbor in grapes. Root pruning and stalk damage by cultivating equipment is also a constant hazard. Effective herbicides that can eliminate mechanical damage and control weeds not reached by cultivators are needed. Recent investigations at Prosser, Washington, have shown that an annual application of diuron or simazine controls annual weeds without crop injury. These herbicides are important new tools to increase production efficiency. Additional herbicides are sorely needed to control perennial grasses such as Johnsongrass in important production areas in the West.

Strawberries -- Strawberries are poor competitors with weeds and are quickly overgrown by successively emerging weed populations. Mechanical cultivation is ineffective beyond the first few weeks after planting because runner development prevents close cultivation and the scarcity and cost of hand labor for weeding have caused reductions in acreage. Herbicides and effective methods of using them are needed to restore economical production. Recent studies have shown that EPTC and its analogs have a high level of crop selectivity and herbicidal effectiveness in strawberries. Soil incorporation improves herbicidal efficiency reducing the amounts of these herbicides required and thereby improving their selectivity. Most promising of these analogs is ethyl-di-n-butylthiolcarbamate.

INSECT CONTROL
Entomology Research Div., ARS

Problem. Hundreds of insects and mites are pests of deciduous tree fruits, tree nuts, grapes and berries grown in the United States. Some occur regularly in destructive numbers over wide areas; others are sporadic or local in their occurrence. They cause direct damage to the crops and some of them transmit serious plant diseases. Since biological, cultural and other methods of combatting these pests have not been sufficiently effective, insecticides are depended on for their control. Continuing research is necessary to provide for changing needs. The development of resistance to insecticides in certain insects and mites, the occurrence of insecticide residues on fruits and berries, and the detrimental effect of insecticides on beneficial insects and on wildlife are complicating factors. There is a continuing need for more effective, more selective, economical, and safer insecticides; and for alternative types of insect control involving attractants, repellants, and growth-affecting materials, including chemosterilants. Less intensive spray programs to minimize residue problems and permit maximum effectiveness of insect parasites, predators, and diseases should be developed. More research is needed to develop integrated chemical-biological control programs to realize the maximum benefit of the respective control agents. Research is required to determine the role of insects in the transmission of important diseases affecting the production of these crops, to discover the insect and mite vectors of the diseases and to determine their host preferences, range, and habits. Means must then be developed to reduce or eliminate the vector populations responsible for spread of the diseases. A search should be initiated for insect-resistant germ plasm to be utilized in crop improvement programs, especially those relating to berries.

USDA PROGRAM

The Department has a long-term program involving entomologists, chemists, physiologists, and insect pathologists engaged in both basic studies and the solution of grower's problems. Research on pome and stone fruit insects and nuts is carried on at Yakima and Wenatchee, Wash., Vincennes, Ind., Wooster, Ohio, Kearneysville, W. Va., and Fort Valley, Ga., in cooperation with the respective State Experiment Stations. Similar research on insects and mites affecting pecan production is carried on at Albany, Ga., and Shreveport, La.; on grape insects, in cooperation with the Ohio Experiment Station, at Wooster, Ohio; and on berry insects at

Beltsville, Md.; and at Riverside, Calif., in cooperation with the California Experiment Station. Research on the role of insects and mites in the transmission of plant diseases is carried on at Riverside, Calif., Corvallis, Oreg., Wenatchee, Wash., and Fort Valley, Ga., in cooperation with the respective State Experiment Stations. Research on pecan insects, cooperative with the Florida Experiment Station, was discontinued at Monticello, Fla., in September 1961, and the resources utilized to strengthen the program on pecan insects at Shreveport, La. Cooperative work with the Wisconsin Experiment Station on the latent viruses of stone fruits was discontinued at Madison and Sturgeon Bay, Wis., in June 1962, and the funds shifted to insect vector studies headquartered at Riverside, Calif. Research on grape insects headquartered at Sandusky, Ohio, for many years was transferred to Wooster, Ohio, in January 1962.

Additional research (3.5 professional man-years) is in progress under a grant of P.L. 480 funds to the Institute of Pomology, Skiernievice, Poland, for studies of the differences in susceptibility and in cholinesterases in various species of spider mites as influenced by acaricides and for studies on the biological control of aphids and scale insects on deciduous tree fruits and effects of pesticides on natural enemies. A portion of a grant of P.L. 480 funds to the Commonwealth Institute of Biological Control, Rawalpindi, Pakistan, (10 professional man-years) for research on scale insects, fruit flies, and mites and their natural enemies in West Pakistan is applicable to insects affecting deciduous tree fruits.

The Federal scientific effort devoted to research in this area totals 24.9 professional man-years. Of this number 2.4 is devoted to basic biology and nutrition of insects; 6.0 to insecticidal control; 5.3 to insecticide residue determinations; 1.0 to biological control; 2.5 to insect sterility, attractants, and other new approaches to control; 0.7 to evaluation of equipment for insect detection and control; 5.5 to insect vectors of diseases; and 1.5 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 47.2 professional man-years divided among subheadings as follows: basic biology, physiology, and nutrition 6.8; insecticidal and cultural control 27.6; insecticide residues 4.4; biological control 2.3; insect sterility, attractants and other new approaches to control 0.5; evaluation of equipment for insect detection and control 1.4; varietal evaluation for insect resistance 0.4; and insect vectors of disease 3.8. All important deciduous fruit-producing States are conducting studies on the basic biology and insecticidal and

cultural control of injurious insects and mites. Most of the work on insecticide residues is being done in California, Oregon, Washington, Illinois, Pennsylvania, New York and Florida. Research on insects and mites attacking grapes and berries, primarily on insecticidal and cultural control and insecticide residues is conducted largely in New York, New Jersey, Pennsylvania, Kentucky, Florida, Michigan, Oregon, and California. Research on insect vectors of stone fruits is conducted in Wisconsin, California, Oregon, and Washington, on vectors of pear decline in California, and on vectors of berry diseases in New York. Research on the basic biology and insecticidal and cultural control of insects affecting pecans is carried on in Florida, Mississippi, and Texas, on almonds and walnuts in California and on filberts in Oregon.

Industry and other organizations, including chemical companies, also conduct research of interest and value on insect pests of deciduous fruits, tree nuts, and berries. Many chemical companies supply materials for testing and they also finance special studies, particularly research on residues. Orchard and berry growers cooperate with State and Federal Experiment Stations and with chemical companies by furnishing plantings, facilities, and materials for experiments. Estimated annual expenditures by industry are equivalent to approximately 15 professional man-years.

REPORT OF PROGRESS FOR U.S.D.A. AND COOPERATIVE PROGRAMS

A. Basic Biology and Nutrition

1. Deciduous Fruit and Nut Insects. Basic biological research was confined primarily to movement studies of the pear psylla and the seasonal development of the peach twig borer in Washington as a basis for improving the timing of spray applications. The pear psylla moves for considerable distances in the early spring and fall and to some extent as early as February and as late as November. Little or no movement occurs from about mid-April to mid-September. First-brood larvae of the peach twig borer appeared in orchards the first week in June and second-brood larvae about July 15. There was evidence that spring-brood moths move about **in orchards very little** and that first-brood moths move about **extensively**.

Ability to provide large numbers of insects at all seasons of the year is a prerequisite for an uninterrupted research program. This requires knowledge of the factors governing development of test species, particularly their environmental and nutritional requirements. In Indiana a satisfactory method for rearing the red-banded leaf roller continuously on an artificial medium has been developed and progress has been made on rearing the codling moth in a similar

manner. In cooperation with the Florida Experiment Station progress has been made on the development of an artificial rearing medium for the hickory shuckworm. Further work is necessary to adjust the nutritive elements in the modified wheat germ medium and to determine environmental conditions needed to induce egg-laying consistently and in numbers.

At Beltsville, Md., the mass production of Drosophila flies is being accomplished with a modification of a standard laboratory technique. About 2 million flies can now be produced with about the same labor costs formerly required to produce about 75,000.

At Wenatchee, Wash., studies of the effect of plant nutrition on mites showed that N, P and K deficiency in peach seedlings did not influence reproduction significantly except that fewer eggs were laid and mortality of adult mites was significantly greater on plants deficient in nitrogen. Foliar nutrients, such as boron, nitrogen, manganese chelates, zinc, and iron had no significant effect on egg laying and mite mortality. On the other hand egg laying was reduced significantly on apple seedlings deficient in N, P, and K but not on pear and on cherry only by a deficiency in P. Mortality of mites was also greater on pears deficient in P. No marked effect on egg laying and mortality of mites was found due to heavy residue in the soil of any of the more commonly used insecticides. In West Virginia leaf analyses over a 3-year period indicated a possible correlation between increases in leaf sugar content of apple leaves following use of DDT and Sevin and increases in mite populations.

2. Insect Vectors of Viruses. Knowledge of the overwintering habits of Homalodisca coagulata in Georgia has contributed materially to the research on control measures to prevent or retard spread of the phony peach virus. Similar studies of the vector Oncometopia undata have yet to reveal its overwintering habits. Attempts to find eggs, nymphs, or adults during January and February have been unsuccessful. In 1961 the first adults were collected early in March.

Comb-like tibial spines on four genera of Tettigellinae were studied in Georgia to determine their significance in the oviposition operation of phony peach virus vectors. These structures were most highly developed in the females of those species that cover the egg clusters with a waxy, chalk-like exudation produced by the females, particularly Oncometopia undata, O. nigricans, and Homalodisca insolita, and were similar in both males and females of species that do not produce the waxy substance, as Cuerna costalis and Aulacizes irrorata.

The need to separate the sexes of phony peach virus vectors before they become adults led to a search for suitable characters. Characters found in the fifth instar nymphs on structures that correspond to the plates of the genital capsule in adult males and the pygofer of adult females now permit accurate separation of the sexes in all three of the most important vectors.

Eriophyes insidiosus, the only known vector of peach mosaic virus, is present beyond the limits of peach mosaic distribution in eastern Texas at least to Georgia, but not in important peach-producing areas in northern California, the Pacific Northwest, or the Midwest. Recent special detection surveys in all peach-growing areas of northern California revealed its presence only as far north as San Luis Obispo County, an extension of only about 100 miles above its previous known range. Again the vector was not found in Washington or Oregon. In Colorado vector populations were extremely light, possibly because of the effect of sprays applied to control other insects.

An important outgrowth of the peach mosaic vector survey program has been the finding of a number of mites that closely resemble Eriophyes insidiosus on a variety of rosaceous trees or shrubs. At least eight such forms have been collected on as many kinds of common woody plants. Work in progress, as yet incomplete, seeks to determine whether certain of these mites may be (1) the mosaic vector species, or (2) species closely related to the mosaic vector and capable of transmitting peach mosaic virus. Comparative studies that were continued in California on the morphology of E. insidiosus and closely similar forms on pears, cherries, and other hosts, indicated that E. insidiosus and the similar form responsible for blistering on pear are distinct species, with the latter occurring in California, Oregon, Washington, Utah, Colorado, and Wisconsin. Likewise, the newly discovered vector of cherry mottle leaf virus, an eriophyid mite that resembles E. insidiosus closely, is also believed to be a distinct species. This mite vector was found on Prunus emarginata from northern California to Washington and on cultivated sweet cherry.

B. Insecticidal and Cultural Control

1. Codling Moth. The codling moth has a remarkable ability to become resistant to insecticides and to rebound from adverse conditions to maintain its status as a serious pest. DDT and, to a lesser extent, DDT-parathion sprays, are less effective than formerly in codling moth control on apples in many localities. In

some cases increased numbers of applications and/or amounts of insecticides per unit volume of spray have resulted in DDT harvest residues close to the tolerance of 7 p.p.m. This indicates that there is a limit to which growers can use increased dosages and number of applications to overcome the decreasing effectiveness of DDT. Research is therefore being continued on newly available insecticides for codling moth control.

Guthion alone or in combination with DDT or Sevin, or Sevin alone, is currently giving outstanding control. Addition of oil improved control with sprays containing Sevin but not with sprays containing Guthion or malathion. The extenders WARF and TD-244 failed to increase the effectiveness of DDT. In preliminary screening tests of newly available compounds Bayer 37344 and Stauffer 3413 showed promise for codling moth control in Indiana, Washington and West Virginia. In laboratory tests in Indiana and Washington Bayer 32,651, 41,831, 44646 and 46676; American Cyanamid EI-38023; General Chemical 3707; Hercules 7522H, 8717 and 9699; Hooker 1422; Menazon; Monsanto CP-40273 and 40294; Niagara 5943; Shell SD-8448; Stauffer R-1504 (Imidan), N-2310, N-2790, and N-2860; Upjohn 12927; and Zectran were found worthy of further trial. In a limited field trial the residual effectiveness of Zectran was superior to that of Bayer 37344, Imidan, Monsanto CP 40294 and American Cyanamid 43064 but not to that of Sevin. Bayer 37344 was superior against adult moths, being the only one of the materials to kill a high percentage after weathering 14 days.

Studies of Guthion residues on apples in Washington provided an explanation for its long period of effectiveness against the codling moth. Deposits disappeared at a faster rate from foliage than from fruit for about 2 weeks, and then declined to about the same level on both foliage and fruit at the end of 3 weeks. Subsequent losses were at about the same rate for up to 8 weeks. The loss on both fruit and foliage was about 50% after 3 weeks, about 67% after 4 weeks, with little loss occurring thereafter up to 8 weeks.

Results obtained in four cooperative tests with growers further demonstrated the effectiveness of a 2-application Guthion spray program for controlling the codling moth in the Yakima, Wash., area. In Indiana a three-year rotation program built around schedules containing organic phosphorus, chlorinated hydrocarbon, and carbamate insecticides maintained excellent control of the codling moth and other orchard insect and mite pests for the second year, although there were indications that Guthion is gradually becoming less effective in controlling mites.

2. Orchard Mites. No one approved miticide can be depended upon to control all species of mites in all orchards. This is an alarming situation brought about by the occurrence of insecticide-resistant strains of mites. An accelerated program of screening promising new insecticides, antibiotics, and other types of compounds that might inhibit mite activity and development has been activated along with studies to determine the influence of tree vitality, nutritional and hormone sprays, insecticides and fungicides on mite populations.

In screening tests of 150 or more newly available compounds in Indiana and Washington, the following were sufficiently promising to justify further trial: OW-9 (an analog of Aramite); American Cyanamid 43064, 43073, 43356 and 47031; Bayer 21,097, 25,141, 37,344, 41,522, and 45,432; Monsanto CP-40,272 and CP-40,273; Niagara 9044; Shell SD-3562 and SD-7438; Stauffer N-2860, R-1448, R-1504, R-1505, and R-1571; and Zectran. American Cyanamid EI-43064, 43356, and 47031; Bayer 25141; and Shell SD-3562 showed some promise as systemic insecticides.

In orchard tests in the Yakima Valley of Washington, Tedion, 1 pound 25% wettable powder and Kelthane, 2 pounds 18 $\frac{1}{2}$ % wettable powder per 100 gallons, usually in the first and third cover sprays, gave excellent control. Tedion was most effective in a preventive as contrasted to a suppressive schedule. Bayer 30686 (Eradex) and Shell SD-3562 gave excellent results but the latter material was markedly phytotoxic. Fair to poor results were obtained with 7 additional experimental materials.

In West Virginia prebloom applications were generally less effective than in other areas in maintaining European red mite control. In Indiana no one material tested in prebloom or early postbloom applications was outstanding for controlling mites on apples. Chlorbenseide and Trithion included in the first and second cover sprays at half the single-application dosage were more effective than a single full-strength application at the pink stage of bud development. Ovex performed in a similar manner. No advantage accrued from using oil in combination with chlorbenseide or Trithion in prebloom applications. Tedion was less effective in prebloom applications than chlorbenseide or ovex but in postbloom applications it was highly effective. A pink bud application of chlorbenseide or two applications of Tedion at the time of the first and second cover sprays proved more effective than a green tip application of oil. Indopol polybutene, a sticky material that traps mites, showed promise for use early in the season. Later its sticky nature may be objectionable and cause some injury. It was more

effective when applied after bloom than when applied before bloom. A root zone injection of phorate, 5 ounces per tree, at the time of the pink stage of bud development maintained excellent mite control.

In Ohio foliar sprays of DDT were followed by a much greater increase in populations of the European red mite on peach trees than occurred on trees receiving only ground sprays of DDT or DDT plus miticide. Superior type soluble dormant oils applied at dormant, delayed dormant and pink stages of tree development did not cause any noticeable injury to 10-year old Elberta peach trees and gave excellent control of mites throughout the season. In preliminary field tests on peaches Indopol polybutenes gave quite good control of mites in summer applications but not in a dormant spray. In Indiana two summer applications 7 days apart of Stauffer R-1504, Naugatuck OW-9, Niagara 9044, Zectran, ethion, Bayer 37344, and Trithion gave excellent control of mites whereas a single application failed to do so.

Use of dimethyl sulfoxide (DMSO) and other solvents was studied in Washington as aids in moving pesticides within plants by injection and for increasing the systemic action of pesticides applied in sprays or in pastes applied to the bark of trees. Most of the pesticides tested, including DDT, BHC, dieldrin, Sevin, Kelthane, Guthion and others not generally systemic, and a number of antibiotics moved to the leaves following injection of DMSO solutions into the tree trunks, as evidenced by phytotoxicity and effects on mites. There remains the need to work out practical methods of utilizing this discovery.

3. Plum Curculio. Methods for controlling this pest that will obviate the need for hazardous insecticides are desirable. Reports of the possible occurrence of parathion-resistant strains suggest the urgency of further insecticide studies.

In an orchard test in Georgia, Guthion was outstanding and superior to parathion-dimethoate or parathion-dieldrin split schedules, parathion, and Sevin. Dimethoate at 1 pound per 100 gallons was injurious to peach trees. At $\frac{1}{2}$ pound Bayer 25154 was very effective but phytotoxic to peach foliage. Bayer 37344 was promising. Other promising materials caused no injury.

In laboratory screening tests of new insecticides Stauffer R-1504 and Monsanto CP 40294 were outstanding, and Bayer 37344 and 4183 very promising. Shell SD-3562, GC 3707, UC 8305 and UC 10854 deserve further evaluation. Other materials lacked residual value or both knock-down and residual value. In field tests on peaches in Indiana Guthion sprays and dusts and Sevin sprays gave excellent control of the plum curculio but a Sevin dust was less effective.

In cooperative field tests on plums in Ohio dieldrin, endrin, Guthion, and Sevin controlled the plum curculio in that order of effectiveness, ranging from 100% for dieldrin to 94.8% for Sevin. R-1504, which was superior to other experimental materials, and Zectran showed promise in controlling the plum curculio on plums but caused some injury. The polybutenes were completely ineffective and NIA 5767 was not promising.

In Georgia, soil applications of chlorinated hydrocarbon insecticides continued to control the plum curculio several years after application. Aldrin, dieldrin and heptachlor, with dosages of 2 to 4 pounds per acre, remained effective for 8 or 9 or more years. In an isolated orchard unsprayed since the soil was treated with aldrin in 1957 only 6.4% of the fruit was wormy at harvest in 1961. Cooperating entomologists in Ohio also reported good control with a soil application of aldrin or dieldrin. Preliminary results of tests of soil applications of aldrin or dieldrin in Indiana, Kentucky and New Jersey were poor. Type of formulation appeared to be unimportant for this usage. Bioassays of orchard soils from central Georgia peach orchards indicated that soil accumulations of insecticides from foliar sprays are becoming heavy enough to reduce the ability of curculio grubs to reach the adult stage and emerge.

4. Deciduous Tree Fruit Borers. Borers, particularly the peach tree and lesser peach borers, are among the most serious pests of stone fruits, weakening and shortening the life of infested trees.

In Georgia endrin and Thiodan were outstanding for control of these borers when used in trunk sprays to prevent peach tree borer damage to peaches. Dieldrin was only a little less effective and not improved by an extender, Arochlor 5460. Sevin was ineffective. The systemic insecticide phorate applied to the soil was also ineffective. In Indiana peach tree borer control with two applications of Thiodan was outstanding and a single application to the trunks and scaffold limbs also gave substantial but not complete reduction of the lesser peach tree borer infestation. In other tests endrin (one application), Guthion, Sevin, Thiodan, and a mixed dieldrin-Guthion schedule (3 applications) reduced a heavy infestation of the lesser peach tree borer by about 80%. A single application of dieldrin was ineffective. All treatments gave good control of a light infestation of the American plum borer in peach trees.

Phorate granules worked into the soil under the spread of peach trees in Georgia did not appear promising for controlling the peach tree borer, lesser peach tree borer, or shot-hole borer.

5. Pear Psylla. The problem of strains in the Pacific Northwest resistant to previously effective insecticides was further intensified during 1961 by the apparent occurrence for the first time of strains resistant to Guthion. Hitherto this material was considered to be the only really effective insecticide for summer use to control this insect.

In experimental plots at Yakima, Wash., $1\frac{1}{2}$ pounds of 25% Guthion wettable powder per 100 gallons (600 gallons/acre) gave excellent control when three applications instead of the usual two were made, but at half that rate it failed to hold the population at an economic control level. Dilan, 1 pound of 50% wettable powder per 100 gallons, was equal to Guthion. Eradex (Bayer 30686) gave excellent control and Bayer 37344 and 36205 gave fair control. Bayer 32651 and 44646, Sevin, and phosphamidon were ineffective. Application of Guthion at several concentrations of from 1X ($1\frac{1}{2}$ pounds 25% WP/100/600 gallons/acre) to 8X resulted in excellent control of the pear psylla in all instances. There was practically no difference in the quantity of insecticide deposited by the different spray concentrations regardless of the type of sprayer used to apply them.

In laboratory screening tests at Wenatchee, Wash., Stauffer N-2230, 2404, and R-1504; Menazon, Hooker 1422; Bayer 36205 and 39007; and Niagara 5943 were the most promising of 20 compounds for controlling psylla nymphs, and Zectran and Shell 3562 were the only ones of 18 materials that were effective against adults. Apparent high resistance of the psylla to Guthion in orchards in Gleeed, Wash., was confirmed in a laboratory evaluation.

6. Miscellaneous Insect Pests of Deciduous Tree Fruits. In studies at Kearneysville, W. Va., the root-infesting form of the woolly apple aphid caused malformations that render apple nursery stock unsaleable. Dimethoate, Thiodan, Hercules 5727 and Trithion applied to the tree trunks at the soil surface in each of the 2 years the trees were in nursery rows effected a highly significant reduction in the percentage of infested trees. Forty percent of untreated trees became infested. The most practical dosages remain to be determined. In another test dimethoate, Thiodan or Trithion, as used above to prevent infestation, was not able to bring an established infestation under control. This suggests it is easier to prevent than to suppress infestation.

The oriental fruit moth, long a serious pest of peaches and other fruits until brought under control with DDT, is now increasing in some areas. In Indiana, Guthion sprays and dusts and Sevin sprays gave excellent control on peaches but Sevin dusts were unsatisfactory. In Ohio, two applications of Sevin, 2 pounds 50% wettable powder per 100 gallons of spray containing phytomycin, glyodin, and ferbam, scorched the leaves of quince so much that no further applications were made.

The occurrence of TDE-resistant strains of the red-banded leaf roller has necessitated an expansion of research to find a material that can be used with or instead of TDE to maintain control. West Virginia tests showed that endrin must be applied before larvae reach the third instar to be effective; two and three applications beginning at petal fall were no more effective than one application only at petal fall. Bayer 22408 was slightly superior to endrin. In limited field tests in Indiana, Zectran and Bayer 37344 applied at petal fall were as effective as several of the recommended insecticides. TDE, lead arsenate, Guthion and endrin were effective against first-instar larvae. In laboratory tests Bayer 37344, Zectran, Guthion and endrin killed 100% of the first-instar larvae, TDE 91% and lead arsenate and dieldrin 82%. In Indiana, also, a related species of leaf roller, Platynota flavedana, was controlled effectively by a Sevin spray program. Sevin dust and Guthion spray and dust programs were not satisfactory. Finish of fruit in the spray plots was superior to that in the dust plots, primarily due to the use of sulfur as the fungicide with the dusts and captan with the sprays.

The apple maggot, the most serious pest of apples in some North-eastern and North Central apple-producing areas, cannot be controlled satisfactorily by present insecticides. In northern Ohio, traps showed that apple maggot flies were present from June 27 to about October 3, indicating the long period effective treatment must be maintained. Sticky board traps were superior to Medfly-type plastic traps for capturing flies attracted by the standard dibasic ammonium phosphate-protein hydrolysate bait. Catches were not consistently higher whether traps were placed in trees at a height of 15 feet or at a height of 7 feet. The lack of a satisfactory spray treatment has focused attention on attractants that might be used directly or indirectly in bait sprays for control. In cooperative screening tests in Ohio, no material was found equal to the standard, a mixture of diammonium phosphate and Staley's protein bait No. 2.

Scale insects devitalize deciduous fruit trees and may cause their death if left uncontrolled. Oil sprays most commonly recommended for scale insect control are not always fully effective against some species or when infestations of others are heavy. In Georgia parathion, parathion-dimethoate, and Sevin spray programs, as used to control the plum curculio, maintained the San Jose scale under control and a Guthion program was only slightly less effective. Parathion, malathion, Guthion, Sevin and dimethoate, whether applied during the dormant season or later, were not effective against the white peach scale.

Forbes scale has largely replaced San Jose scale as an important pest in many orchards in the Midwest and East, so much so that it is desirable to know the value of new insecticides for its control. In 1960 field spray plots on apples in Indiana a petal fall and seven cover sprays of Delnav, DDT, Bayer 22408 and 29493, and SD-5533 did not prevent an increase in the infestation of Forbes scale. Guthion and Sevin held populations to a low level, as previously.

The feeding of sucking bugs causes peaches to become deformed. The number and variety of species involved and the length of the period they are active make their control difficult, especially since no one available insecticide is effective against all species. The most effective treatment known (a dieldrin-Guthion combination) can be expected to reduce injury only by about 63%. In continuing cooperative research with the Ohio Experiment Station, Indopol polybutene was superior to Zectran, NIA 5767, and R-1504, but the percentage of the crop injured was reduced by only 63.3%. In another case endrin was superior to Sevin, Guthion, and dieldrin but reduced plant bug populations by only 75%. In still another instance dieldrin and Guthion alone and in combination were superior to Thiodan alone or with Guthion but control was below commercial standards.

Several species of aphids are well-known, injurious pests of deciduous fruits. A number of insecticides are highly effective in reducing damaging populations but lack the residual qualities needed to prevent reinfestation in a short time. A more persistent aphicide or another type of treatment is needed. In Washington Niagara 5943, Bayer 44646, Upjohn 12927, Stauffer R-3413, and Zectran were most promising of 24 experimental insecticides evaluated for controlling the apple aphid and Stauffer compounds N-2404, B-8760, N-3051, N-2230 and B-8778 and Niagara 5943 were most promising of 10 compounds evaluated for controlling the green peach aphid.

The cherry fruit flies, Rhagoletis cingulata and R. fausta, continue as important pests of cherries because of their occurrence in maximum numbers as the cherries reach maturity. This imposes a residue limitation on the insecticides that can be used in their control. In Ohio, the newly developed standard bait of dibasic ammonium phosphate with Staley's protein insecticide bait No. 2 was superior to the previous standard, ammonium carbonate, accounting for 77% of the fruit flies captured. This bait attracted more adults when exposed in combination with sticky board traps than when exposed in Medfly plastic traps. Two field tests of malathion bait sprays, so effective against certain other fruit flies, gave discouraging results, permitting 5% or more of the cherries to become infested. Near perfect control is needed, particularly for cherries destined for commercial canneries.

Sevin, an insecticide effective against a wide range of deciduous fruit insects, has reduced the set of apples when used in the petal fall and early cover sprays. In a test in Indiana, it had this same effect in 1961 when used in the pink-bud period of apple development, reducing set 60% on Jonathan Clark-dwarf trees and 23% on Starking Clark-dwarf trees. On peaches, there was little or no effect on set.

For years injury caused by the feeding of nymphs of the periodical cicada on the roots of mature apple trees was not recognized. Recently it has been found that such feeding may cause the decline and ultimate death of trees. Soil applications of phorate and Sevin failed to control the cicada in a heavily infested apple orchard in Indiana.

Renewed efforts have been made to find combinations of insecticides compatible with recommended fungicides for use in controlling scale insects, mites and aphids before bloom of apples. In tests of possible effective combinations in Indiana, mixtures of oil sprays and the fungicide, dodine (Cyprex), were compatible but unstable when wettable powder formulations containing Guthion, malathion, Sevin, Trithion, Genite, BHC, Niacide, ferbam, or zineb were included. Emulsifiable concentrates, containing Guthion, demeton, and dimethoate, were readily mixed in sprays with oil and dodine, but two formulations of emulsifiable malathion were not satisfactory when combined with the oil and dodine.

7. Pecan Insects. Work was continued on the development of methods of preventing or suppressing insect and mite damage to pecans in cooperation with the Florida Experiment Station (formal cooperation discontinued September 30, 1961) and in Georgia and Louisiana. Staffing for an expanded program in Georgia was completed and facilities improved.

The hickory shuckworm received major attention in Florida and Georgia in a continuing effort to find a satisfactory treatment for this difficult pest. In field spray tests in Florida, EPN and Guthion gave excellent control of a light infestation of the shuckworm regardless of the type of formulation, wettable powder or emulsifiable concentrate, when used in a 3-application schedule. Dosage, likewise, was not important within the range tested. In one experiment in Georgia, Thiodan and Phosdrin wettable powders and Guthion emulsifiable concentrate were as effective as EPN and Guthion wettable powders. Differences in control were not significant and the quality of the nuts was good in all cases. In a second experiment EPN emulsifiable concentrate and EPN wettable powder alone and with a tung oil sticker reduced shuckworm infestation to a low level and were superior to Diazinon, which was not very effective. The quality of nuts harvested from the Diazinon plot was equal to that of nuts from the EPN plots.

The pecan nut casebearer, at times the number one pest of pecans, was uncommonly abundant in Florida and in portions of the more western part of the pecan belt. In Louisiana, conventional ground applications of recommended insecticides were generally superior to aircraft applications.

The pecan leaf casebearer, for years a minor pest, reached damaging population levels in many orchards in the Southeast. In Georgia, aerial applications of a 10% malathion dust at 20 pounds per acre gave effective control of a light infestation. However, the minimum effective dosage remains to be determined. EPN, Diazinon, and Bayer 29493 at 2 pounds of formulated wettable powder per 100 gallons in 3 applications at 2-week intervals beginning August 11 gave almost complete control of a heavy infestation. The indications are that summer applications may give more dependable control than spring applications.

The pecan weevil occurs sporadically throughout the area in which pecans are grown, and in the absence of control measures, may cause serious crop losses. When pecan orchards are used for pasture, there is need for insecticides that will leave short-lived, less hazardous residues on the orchard cover than DDT or toxaphene, the currently recommended materials. Results of tests of soil insecticides, heptachlor, aldrin, and dieldrin, were inconclusive and need confirmation in further experiments. In a test in Arkansas, methyl parathion at the rate of $1\frac{1}{2}$ pounds in 10 gallons spray per acre, gave poor kill of the pecan weevil but excellent control of the walnut caterpillar.

The pecan phylloxera, a primary pest of pecans in southwestern U. S., continued to spread and to cause severe damage in infested orchards in which it was not controlled. In Louisiana indications were obtained that aircraft may be utilized for the application of insecticides for control as well as ground machines. An aerial application of BHC, $1\frac{1}{4}$ to $1\frac{1}{2}$ pounds gamma BHC in 15 gallons spray per acre, prevented heavy losses of foliage due to phylloxera damage. Malathion at 3.2 pounds per acre was slightly less effective than BHC.

There is an urgent need for data on the effect of aphid feeding and of the honey dew secreted by some species on the productiveness of pecans. Continued cooperative studies with the Crops Research Division in Louisiana have thus far yielded little information because of inability to control the black-margined aphid. Demeton and schradan, the better available insecticides, have failed to give adequate control of this aphid. Against another species, the black pecan aphid, an aerial application of 0.43 pound demeton in 5 gallons of spray per acre gave much faster kill than one of 0.86 pound parathion per acre; after approximately 24 hours there were very few live aphids in either plot.

In Louisiana, a little-known leafminer, Nepticula sp., reached outbreak proportions in 1960 and reappeared in numbers in 1961. A dilute parathion spray, 2 pounds 15% wettable powder per 100 gallons, was adequate to prevent serious damage.

A spittlebug, Clastoptera achatina, an occasional pest of pecans in the Mississippi Valley, became unusually numerous locally in Louisiana in 1961. Thorough application of a dilute spray of 2 pounds 10% gamma BHC or 15% parathion wettable powder per 100 gallons gave good control of nymphs. In other tests Guthion and Thiodan were also effective against the nymphs.

The mite, Tetranychus hicoriae, is a continuing problem in pecan orchards. In Louisiana, Kelthane, 2 pounds of an 18 $\frac{1}{2}$ % wettable powder per 100 gallons, was as effective as the standard parathion-wettable sulfur spray.

8. Grape Insects. In Ohio the grape berry moth, long the most serious pest of eastern-type grapes, was controlled effectively with Sevin 85% wettable powder at 3.4 pounds per acre. Sevin 85% wettable powder and Sevin flowable formulations were equally effective. A commercial spreader-sticker, a Triton B-1956-kerosene wetter, and 1 or 2% of a tung oil sticker were about equally effective in increasing deposits of Sevin wettable powder but residues decreased very little over an 8-day period whether Sevin

was used alone or with the wetters and stickers. There was no significant difference in control obtained with Guthion in a spray combination that included a copper fungicide with or without hydrated lime. Standard DDT-parathion and DDT-parathion-malathion schedules continued to give good control.

There have been indications of the occurrence of parathion-resistant strains of the two-spotted spider mite in some Ohio vineyards. In a comparative test of Kelthane and parathion following two seasons in which parathion was not used, both materials gave excellent control.

Several species of gall-forming insects occur in vineyards in tremendous numbers, usually in limited areas, causing great concern. Satisfactory methods of control are not available for most species concerned. Guthion, 18 ounces per acre, in a 5-application spray program failed to control the grape tomato gall but soil applications of phorate at 20 or 40 pounds per acre appeared promising. In an experiment in which untreated vines were heavily infested in 1960, only a few galls appeared on the phorate treated vines; considerable residue was found in the foliage but none in the berries at harvest. No infestation occurred on untreated vines in this vineyard in 1961 or on 1960 treated vines that were untreated or retreated in 1961; however, a considerable amount of phorate was found in the foliage in 1961 on vines treated in 1960.

The grape cane girdler is sufficiently injurious at times to create a need for an effective method of control. No such method has been available. In Ohio Guthion (3 applications) applied to control the grape tomato gall gave a very high degree of control of the grape cane girdler but Sevin (2 applications) applied to control the grape berry moth was ineffective against the grape cane girdler.

Work on vectors of Pierce's disease of grapes in Georgia was concluded with the publication of a report on the insects found to be vectors.

9. Berry Insects. In California, phorate and Di-syston continued to give good control of spider mites on strawberries when used as systemics in the soil before planting. Applied at 1 and 2 pounds per acre, respectively, in December these materials controlled the mites through the following May. Also in California, Kelthane applied to the foliage of strawberry continued to give good control of spider mites and was superior to other materials tested.

At Beltsville, Md., the role of lygus bugs in causing damage to strawberries known as "button berries" was confirmed; also, that insecticides detrimental to pollinating insects should not be applied for lygus bug control after strawberries begin to bloom.

10. Drosophila. Drosophila spp. are often nuisance pests in and around fruit and berry plantings and processing plants. In field tests in Ohio a Sevin-malathion spray applied 3 days prior to harvest effected about 75% reduction in Drosophila infestation in harvested grapes and pyrethrum, malathion, Sevin and Diazinon dusts reduced infestation appreciably. However, 3.4 pounds Sevin per acre failed to reduce a Drosophila infestation appreciably when large numbers of bird-damaged and cracked grape berries were present. Grape pomace spread in the vineyard immediately after pressing did not contribute to the Drosophila problem, apparently drying out too rapidly to serve as a suitable breeding medium.

C. Insecticide Residue Determinations

1. Deciduous Tree Fruits and Nuts. In Indiana apples were sprayed with Sevin, Guthion, DDT, or malathion in combination with captan and with or without 2% Indopol polybutene H-100. The polybutene had no effect on original deposits of DDT and Guthion, but decreased amounts of Sevin and malathion deposited. The persistence of DDT and Sevin was increased by the polybutene, but there was little effect on the persistence of Guthion and malathion.

Residue studies of some of the newer insecticides in Indiana, Ohio, Maryland, Kentucky, Washington and West Virginia showed (1) that a measurable residue may remain at harvest if endrin is used after apples are present on the trees. Since endrin is approved for use on apples on a no residue basis, it should not be applied in cover spray applications to bearing trees with a crop; (2) harvest residues of Tedion on apples were well below the established tolerance of 2 p.p.m. from applications 7 to 28 days before harvest in Indiana and on apples sprayed according to recommendations in Washington; (3) in Indiana harvest residues of Kelthane and Tedion on peaches sprayed 7 days before harvest were well below the established tolerances of 10 and 7 p.p.m., respectively, while a Sevin spray applied 1 day before harvest resulted in a harvest residue slightly in excess of the approved tolerance of 10 p.p.m. Residues from application of a Sevin dust did not exceed 1 p.p.m. Brushing peaches to improve their appearance reduced harvest residues about 50%; (4) residues at harvest resulting from application of Sevin to cherries in Ohio 0 to 9 days before harvest were well below the tolerance of 10 p.p.m. on or before the second day after application; and (5) harvest residues of Thiodan on peaches resulting from recommended usage for borer control were well below the established tolerance of 2 p.p.m.

Analyses in Indiana indicated that certain systemic insecticides may occur in leaves of fruits in sufficient quantity to control aphids and mites without appearing in the fruit in significant amounts. Significant residues of phorate were found in the foliage of grapes but none in berries from vines receiving 10 pounds phorate per acre as a soil treatment. Berries from vines receiving 20 pounds per acre had a small amount in them at harvest, 1.5 p.p.m. When phorate emulsion concentrate was injected into the soil about apple trees, there was a maximum concentration of the insecticide in the foliage after about one month. Phorate from a granular formulation did not reach maximum concentrations in the trees until August. Di-syston reached its maximum concentration in foliage at the end of May. Fruit samples collected in July, August, and September had only zero to 0.1 p.p.m. of residue.

D. Biological Control

1. Deciduous Fruit and Tree Nut Insects. Problems associated with the use of insecticides have increased interest in other methods of controlling insect pests. Special attention has been given to the evaluation of insect pathogens. In large scale tests initiated in Indiana and West Virginia in the fall of 1960, the DD-136 nematode program failed to protect a high percentage of the apples from codling moth damage in 1961 even though the ability of this organism to kill a high percentage of the worms in bands on the tree trunks was confirmed. In West Virginia, parasitization of larvae in bands was unusually high. Susceptibility of the organism to dryness seems to be responsible for its failure in control. The organism also failed in a test on periodical cicada nymphs in the soil.

In Indiana, the pathogens, Bacillus thuringiensis and B. soto, were ineffective in codling moth control but in Georgia B. thuringiensis showed promise for use to control the peach tree borer. In the spring of 1961 not a single live borer was found in trees treated with this material twice a month for six months from May to October, 1960, and only 2 per tree were found following 6 monthly treatments during the same period. Trees receiving a single application of the pathogen averaged 14.2 borers each and untreated trees 19.3.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Deciduous Fruit and Tree Nut Insects. Sterilization of insect populations by radiation or with chemicals is a possible approach to control or eradication of insects that can be sterilized without behavior breakdown. In Washington, the codling moth proved to

be most susceptible to sterilization by gamma radiation without affecting its vigor when exposed in the pupal stage immediately before adult emergence. Exposure to different dosages from 20,000 to 40,000 r (roentgens) had varied effects on adult emergence and fertility of males. Each rate of exposure within this range caused complete sterility of females as determined by cross breeding with non-treated males. None of the eggs from non-treated females crossed with males treated with 40,000 r produced moths while a small percentage crossed with males receiving lesser exposures did so.

In another test of gamma radiation Drosophila melanogaster females mated with males exposed to 5 kr in the larval stage, 10 to 20 kr in the pupal stage, or 20 kr in the adult stage in Maryland deposited the normal number of eggs, none of which hatched. At the same dosages females treated in the pupal or adult stage and mated with untreated males produced few or no eggs and females irradiated in the larval stage produced fertile eggs but in smaller numbers. The longevity of males or females irradiated in the pupal or adult stage was not affected while the longevity of those irradiated in the larval stage was reduced. In multiple mating tests untreated female flies mated with irradiated males produced sterile eggs until a subsequent mating with untreated males after which they produced viable eggs that developed into adults. Untreated female flies mated with normal males produced viable eggs and continued to do so after a subsequent mating with irradiated males. In limited tests sterile and normal males in the ratio of 5 to 1 gave 55 to 60% reductions of the progeny of normal females with which they mated.

In Washington favorable results were obtained from dipping codling moth eggs and pupae in solutions of chemical sterilants, but observations made thus far have been exploratory.

In Georgia no olfactory sexual attraction between the sexes of the plum curculio was observed, but in preliminary tests with the chemosterilant aphoxide (ENT-24915) plum curculio males allowed to feed for 3 days on treated apples were nearly completely sterile. External applications of aphoxide to adults and larvae failed to produce sterility. Females that fed on a 1% solution of aphoxide produced viable eggs. ENT-26316 also had a chemosterilant effect on the plum curculio but less than aphoxide.

In Indiana 25 chemosterilants tested against the two-spotted spider mite in the laboratory exhibited different modes of action. ENT-25297, 32149, 50004, and 50005 were effective when used in foliar sprays, ENT-50003 and 50005 were effective as systemic insecticides, and ENT 3582, 17185, 25297, 25301, 32149, 5003, 5004, and 5005 depressed reproduction.

Further studies at Wenatchee, Wash., of Acti-dione, an antibiotic, showed that it controls mites by a systemic action through the plants that inhibits egg laying. Several derivatives of Acti-dione performed in a similar manner but to a much lesser extent. A number of antibiotics used in medicine and anti-tumor and viricidal drugs tested were ineffective. Five coded glutarimide compounds, ENT 26258, 26259, 26260, 26261, and 26262, inhibited egg laying by mites, but to a lesser extent than Acti-dione. The antibiotics Streptovitacin A and Cytovirin were equal to Acti-dione in activity against mites. Mycostatin, Amphotericin, and Hygromycin B inhibited egg laying but to a lesser extent than Acti-dione. Most of the antibiotics that affected egg laying caused some adult mortality. Acti-dione is too toxic to apple and pear trees to permit its use in field tests. On mature peach trees this material had only a slight injurious effect on leaf buds at concentrations of 50 and 100 p.p.m. and gave fair control of mites for about 4 weeks.

In further studies at Wenatchee of the effect of antibiotics on reproduction and mortality of the apple aphid and green peach aphid, there was not much evidence of any action on ovarian and embryonic development but relatively low concentrations of a few of the materials, such as Cytovirin, cycloheximide, and Streptovitacin A, caused considerable mortality of adults.

In Maryland a 1% apholate bait gave promising results in producing sterility in Drosophila adults. In limited tests no progeny developed from treated females mated with treated males and very few developed from untreated females mated with treated males. Apholate-fed females produced very few eggs; whereas normal females mated with treated males laid a normal number of eggs of which very few hatched. Longevity of males did not seem to be affected by the treatment.

Successful efforts of studies of sex and chemical sterilants for the gypsy moth and subtropical fruit flies has stimulated a search for similar attractants for some of the major insect pests of deciduous tree fruits and nuts.

In Indiana no response was obtained when codling moth adults were exposed in the greenhouse and field to preparations of extracts of virgin female or male moths or to similar preparations from the gypsy moth or the synthetic gypsy moth attractant. In Georgia extracts prepared from the female hickory shuckworm and plum curculios were unattractive to natural populations. In Ohio similar negative results were obtained with extracts from male and female abdomens and from heads and thoraces of the apple maggot.

The presence of a peach tree borer sex attractant was indicated by Georgia studies. Male borer moths exhibited definite responses to an extract prepared from abdomens of female moths but not to extracts from other body segments. In the initial tests live females were more attractive than the extract from female abdomens. This suggests the possibility that more attractive extracts can be developed. In Indiana promising results were obtained in preliminary studies with the lesser peach tree borer. Four traps, each baited with a virgin female moth, attracted an average of 20 male moths.

Special efforts have been made in Florida, in cooperation with the Florida Experiment Station, to find a chemical attractant that can be used to control the hickory shuckworm. Exposure of about 100 candidate chemical attractants in 1961 and 1962 failed to reveal one with any promise.

In Indiana ammonium carbonate was more efficient than ammonium phosphate as a lure for the walnut husk fly. Pyridine was effective as a lure but evaporated rapidly. Limited trap operations in northern Ohio showed that the adult flies were active from July 18 to October 6. This fly is a widespread pest of black walnuts for which better control measures are needed. An attractant that could be used effectively in a bait spray would be invaluable.

In preliminary laboratory tests in Maryland a sample of ENT 400-F Super from the Northern Utilization Research and Development Division showed promise as an attractant for Drosophila melanogaster adults. Although about 3500 samples have been tested (1300 in 1960 and 260 in 1961), this is the first one to compare consistently and favorably with the standard.

F. Evaluation of Equipment for Insect Detection and Control

1. Deciduous Fruit Insects. In Washington the deposit of Guthion at 12 pounds of 15% wettable powder per acre in 800 (standard), 400, 200, 100, or 50 gallons of water applied with a conventional air-blast sprayer and in 60 gallons of water with a Turbo-Mist concentrate sprayer was practically the same at the 6- and 12-foot levels in trees but at the 18-foot level it decreased to some extent with increase in spray concentration. There were no codling moth injured fruits in any of the plots at harvesttime and no differences in codling moth control were found by biological assay of residues at the 12-foot level due to spray concentrations or differences in the machines with which the sprays were applied.

In Washington application of a program of 8 pounds of 25% Tedium wettable powder in the first cover spray and 16 pounds of 18 $\frac{1}{2}$ % Kelthane wettable powder in the third cover spray at rates of 800, 400, 200, 100, and 50 gallons of spray per acre with an air-blast sprayer or at 13.3 X in 60 gallons of water per acre with a Turbo-Mist concentrate sprayer maintained mites under control at the 6- and 12-foot tree levels but not at the 18-foot level at 2X (400 gallons per acre) or greater concentrations.

2. Pecan Insects. In Georgia an aircraft application of malathion, 20 pounds of 10% dust per acre, reduced infestation of the first-generation nut casebearer about two-thirds. In Louisiana, when application was made with a Speedsprayer, Guthion gave excellent control of first-generation nut casebearer larvae and was more effective than Thiodan, Trithion, or ethion, each of which gave good control. In experiments in Louisiana results of applications with aircraft for nut casebearer control were inferior to those obtained with ground sprayers but good enough to justify use of aircraft for control of this insect in emergency situations or when other types of application equipment are not available. In these tests malathion at 4 pounds and Guthion at 1.1 pounds per acre were about equally effective and superior to parathion at 1.7 pounds per acre. In general airplane applications of concentrated insecticides were superior to airplane applications of dust formulations.

3. Grape Insects. In tests in Ohio to compare grape sprayers and spraying procedures residue determinations showed that insecticide deposits were not significantly different whether application was made with a hooded-boom or spar-type sprayer or whether it was made with a hooded-boom type sprayer delivering 200 gallons of spray per acre and travelling at 3 miles per hour or when the sprayer delivered 300 gallons per acre travelling at 2 miles per hour.

In continuing tests of an experimental concentrate sprayer increasing the number of nozzles from 2 to 4 and the volume of spray applied per acre did not increase deposits comparable to those obtained with a hooded-boom sprayer. Deposits were 1.8 to 2.4 times greater with the latter machine.

4. Drosophila. Field studies of *Drosophila* populations in Maryland showed the need for a marker to identify field-released chemosterilant-treated adults. Seven water-soluble fluorescent biological stains sprayed on laboratory-reared *D. melanogaster* adults at 1% strength left residues that could be readily seen under a binocular microscope for at least two weeks. The best

stain tested was rhodamine B. The use of biological stains as markers provides a simple and inexpensive method of identifying field-released insects in population studies. In 1961 marked D. melanogaster adults were caught 2 miles from the point of release.

G. Insect Vectors of Diseases

Insects and mites are primary vectors of many virus diseases. Knowledge of the vectors serves as a basis for developing methods of preventing or suppressing spread and for determining the host range and other important characteristics of viruses.

1. Phony Peach Virus. Phony peach virus vector surveys were continued in the Fort Valley and Barney, Ga., study areas from March through October, mainly in support of vector control activities. These showed that populations of the primary vector, Homalodisca coagulata, were at a low level in 1960 and 1961 but increased sharply in the Barney area in 1962. Oncometopia undata was slightly more abundant in 1961 than in 1960.

Twenty transmission tests initiated in Georgia in 1958 to determine the role of dehorned phony virus infected trees as sources of inoculum for spread of the virus by its principal insect vector, Homalodisca coagulata, resulted in 1 additional positive transmission identified in 1961 following 2 positive cases in 1960. Such trees are a danger to spread if not removed promptly. Transmission tests with Oncometopia nigricans, until 1960 a synonym of O. undata, an important vector of the phony virus, and Aulacizes irrorata, in 1960 and 1961, and with Graphocephala coccinea in 1960 yielded no positive results in 1960 or 1961 but O. nigricans appears to have effected transmission in one instance recorded in 1962.

The results of vector control experiments initiated in 1958, in cooperation with the Plant Pest Control Division and Georgia Department of Entomology and continued annually to date, show that a two-spray program of $1\frac{1}{2}$ pounds of DDT per acre applied by airplane to mixed woods where the principal phony peach virus vectors hibernate near peach orchards may be effective. Favorable results reported in 1960 were confirmed by the results obtained in 1961. Initially there appeared to be a direct relationship between the reductions of the vector populations and reductions in the expected number of diseased trees. However, in the Barney, Ga., area in 1962 the incidence of spread of the virus was disappointingly high. The data indicate that the first application should be made the first week in April and the second 30 days later. The

1961 tests were redesigned to measure the effect of reducing the amount of DDT per acre to 1 pound. This may account for the increase in the vector population in 1962.

The systemic insecticide Di-syston killed vectors of the phony peach virus for two seasons in Georgia when applied to the soil about the base of young peach trees at 50, 100, 150, 200, or 300 grams of 10% granules per tree in tests initiated in 1960 and continued in 1961. The vectors ingested lethal doses of the insecticide within 2 to 3 hours of feeding on treated trees and 100% mortality usually resulted in 1 to 3 days until effectiveness declined. Four-year-old Elberta trees showed no phytotoxicity after receiving 100, 200, or 300 grams of the insecticide per tree. Small June-bud Keystone trees were severely damaged with 100 grams per tree. These results suggest a possible treatment for protecting young peach trees from the phony peach virus during the period they are most susceptible to infection.

2. Peach Mosaic Virus. There is still no indication that any insect or any other species of mite other than E. insidiosus is a vector of peach mosaic virus. In one set of 22 experiments in California, E. insidiosus mites from trees infected with both peach mosaic and ring spot viruses transmitted the former but not the latter virus. This provided several ring spot free cultures of peach mosaic virus for Crops Research Division workers. In a second set of 15 experiments E. insidiosus failed to transmit a mild mosaic-like virus commonly encountered in western peaches, including northern California. Thirteen parallel transfers from known mosaic-infected trees gave transmission, giving good reason to conclude that the new mild mosaic-like virus is not peach mosaic. In still other transmission tests apple and pear failed to become infected, a strong indication that these fruits are not susceptible to the peach mosaic virus.

A simple method of rearing E. insidiosus in large numbers is urgently needed to provide specimens for basic studies of the peach mosaic virus. Attempts were continued with varying concentrations of plant hormones to produce young peach seedlings with retarded buds of the type required by this mite for good development. Use of maleic acid hydrazide and parachlorophenoxy acetic acid at concentrations of 1 to 10,000 or weaker provided peach seedlings that superficially had the required characteristics. Thus far, however, repeated transfers of mites to such trees have not been followed by prompt establishment.

In 1961 and 1962 all host trees, 1,643 trees on 19 properties, in an isolated mosaic-infected area in California were sprayed with Diazinon, 2 pounds of 25% wettable powder per 100 gallons, early in May to determine the value of such a treatment in suppressing spread of the virus. Samples of 10 buds from each of two trees heavily infested with mites yielded 1,200 and 1,350 living mites before spraying; similar samples yielded 1 live and 1,100 dead mites on one tree and 2 live and 1,150 dead mites on the other tree 38 days after spraying. At least three years will be required to obtain a valid indication of the effect of the treatment on virus spread.

In preliminary control experiments a fall application of insecticides was about 10% less effective than a spring application in controlling E. insidiosus. Reductions in infestation ranged from 91% for Di-syston, 90% for Schradan, 88% for Diazinon, 83% for parathion, 77% for Phosdrin to 74% for demeton.

3. Latent Group of Stone Fruit Viruses (ring spot, sour cherry yellows, etc.) Because of the increasing interest in the hypothesis that natural spread of ring spot virus may occur through virus-infected pollen, with or without the aid of insects, the cooperative vector search program in Oregon has been reoriented to stress the relationships of ring spot virus to infective pollen and to pollen dispersal. Forty-five vector tests were initiated with 2 strains of ring spot virus, a standard "R-31" and a recurrent ring spot strain, utilizing 4 species of aphids. Experiments were designed to test persistent and non-persistent types of transmission and involved manipulations utilizing sour cherry and herbaceous hosts. Positive results were not obtained in cucurbits; readings in sour cherry will come later.

In cooperative studies in Wisconsin, 100 2-year old virus-free Montmorency cherry trees were planted in four distinct environments in relation to degree of exposure to sour cherry yellows infected plants to study natural spread and the insects found associated with it. Blossoms will be removed each spring as long as practical. There was also carried out in Wisconsin a series of tests with potted trees to determine season of spread of the sour cherry yellows virus, groups of trees being exposed at different periods during the season; and a search was made for vectors of sour cherry yellows virus involving 110 transmission tests with three species of aphids. During the season there were reactions in 14 trees. Careful indexing in 1962 will be carried out to determine if they represent transmission of sour cherry yellows.

4. Miscellaneous Stone Fruit Virus Diseases. The incidence of occurrence of peach rosette, a rapid tree-killing virus, appears to be increasing in Georgia, prompting increased attention to possible insect vectors. The results of 117 transmission tests with about 18 species of Homoptera, mostly leafhoppers associated with natural spread areas, initiated in 1961 are not yet available.

In Washington a new species of eriophyid mite from Prunus emarginata effected 12 successful transmissions of the cherry mottle leaf virus in 21 tests made by the Riverside, Calif., staff. Results of 303 confirmatory tests initiated by Washington Experiment Station cooperators in 1961 should be available before the end of 1962. Transmission tests are also underway with a second eriophyid mite, E. prunidemissa, from P. demissa.

The little cherry virus (sometimes referred to as K and S virus), which is widespread in flowering cherries, is a threat to commercial cherry production, as has been demonstrated by its rapid spread in British Columbia. In Oregon in 1960 transmission tests were initiated with four species of leafhoppers utilizing Sam cherry and several herbaceous hosts, the latter in a search for a host to facilitate future transmission tests. In 1961, 16 additional tests were initiated with three leafhopper species in a further effort to discover a succulent host. Conspicuous symptoms were observed in one celery plant from tests with Macrosteleus fascifrons but confirmatory tests are needed to establish transmission.

5. Pear Decline. The growing acceptance of the belief that a virus may be associated with pear decline and the seriousness of spread in California and other western States prompted vector studies in close cooperation with Federal and State research workers in other disciplines in California in initiating an all inclusive study of the pear decline problem. Initial efforts to determine the possible role of insects and mites in the spread of this disorder were centered on eriophyid mites, logical suspects not being given attention by cooperators. A total of 172 test trees received 52,250 mites of two species separately and in combination. The test trees are being held for possible development of symptoms.

The coincidence of spread of the pear psylla and subsequent occurrence of pear decline in the West casts suspicion on this psylla as contributing to the spread of pear decline. Recent work by the Washington Experiment Station suggests that the psylla carries a toxin into pear trees that creates a condition similar

to pear decline. Surveys for pear psylla in areas where it was not previously known to occur in southern California resulted in its discovery in San Diego County, an area where pear decline appeared to occur in advance of the psylla. The limited known distribution of the psylla in San Diego County suggests its recent introduction. Limited transmission tests utilizing the pear psylla have not yet been completed.

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CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling crops, with emphasis on the preservation of inherent qualities during these processes. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

While research on harvesting equipment and methods has led to much improvement in the reduction of production costs of such crops as grains and forage, much additional work needs to be undertaken, both basic and developmental, in order that all crops may be mechanically handled. Harvesting equipment research for fruits, only recently initiated, has already resulted in sizeable cost reductions, but the potential savings for these crops and vegetables are enormous.

The problems associated with harvesting and handling are interrelated with crop growing, processing, and storage thus necessitating close cooperation with engineers in other research areas and with scientists in other disciplines.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on deciduous fruit harvesting equipment at East Lansing, Mich.; Wenatchee, Wash.; and Davis, Calif. is cooperative with the Experiment Stations in those States, and with producers, and machinery manufacturers. Crops under study include: Apples, pears, peaches, apricots, plums, grapes, blueberries, cherries, and dates.

The Federal engineering effort devoted to research in this area totals 48.4 professional man-years, of which 7.1 are devoted to research on deciduous fruit.

RELATED PROGRAM OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 48.8 professional man-years of which 6.7 were devoted to research on deciduous fruit; conducted in all four regions.

Industry and other organizations conduct engineering research on equipment and methods for the harvesting of crops. Both full line and small manufacturers cooperate in USDA research through loan of equipment. Farm operators and organizations furnish land, equipment, and facilities for evaluation of experimental harvesting equipment. Much of the industrial experimental development of harvesting equipment is highly confidential and is generally not made available to public researchers.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Harvesting is the only step in the growing, handling, and packing of apples that has not been extensively mechanized. It is a major problem because of high costs, periodical shortages of labor, and difficulty of harvesting the entire crop at proper maturity. Growers in all apple-producing areas need techniques and methods which will make harvesting easier and less costly. A unique fork lift attachment for the tractor-mounted picking and pruning boom was designed and constructed. The attachment makes it possible for the worker to empty his picking bag into a bulk box or container without getting out of the "cage." Time studies showed a worker increased his picking rate on fresh market apples by 24.7 percent. The hedging machine was used for pruning the same thirty acres of cherry, peach, and apple trees as in F.Y. 1960 and for pruning the four-year-old tree wall plantings of apples. Results showed that pruning costs were again materially reduced, that a satisfactory job of pruning was obtained and yields were the same as hand-pruned trees. Two types of inertia shakers (hydraulic and pneumatic) and a boom shaker were used to harvest 20 Hubbardson apple trees and 10 Bartlett pear trees. The fruit was collected on self-propelled low-profile frames. Design criteria for both shakers and frames were obtained.

The self-positioning conveyor tube and bin filler elements of the "pick and drop" equipment were redesigned and mounted on a "Steel Squirrel." Time studies on orchard trials with this equipment showed an increased picker output on fresh-market apples of approximately 22 percent as compared to regular picking with a ladder. Preliminary equipment consisting of an adjustable height hopper and an elevator was designed, constructed, and tested in picking hedge row plantings. A 19 percent increase in picking output compared with regular picking methods were obtained.

Bulk box handling of tree fruits. The bulk box handling methods developed under this project have become standard practice in all major deciduous fruit producing areas of the United States and Canada. During the 1960 season, over 50 million bushels of apples, pears, peaches, and prunes were handled in bulk boxes with a resultant saving to the industry of over two million dollars. The water flotation dumper developed last year was used successfully in emptying over 400,000 bushels of apples. Twelve other units patterned after this one have been constructed and used. This project is being discontinued.

Cultivated blueberries are grown commercially in the Mid-Atlantic States, the Great Lakes area, and the Pacific Northwest. Although equipment and methods which greatly reduce the cost of harvesting and packing blueberries have been developed, costs are still rather high and can be reduced further. Follow-up studies of the mechanical picking unit developed on this project showed that over 25 percent of Michigan blueberry crop and about 10 percent of the New Jersey crop was harvested mechanically at less than half the cost of hand-picking. The experimental continuous blueberry harvester was completely redesigned and reconstructed so that spindles will rotate through the canes without injuring them and at the same time vibrate for berry removal. The unit was not field tested during 1961. A semiautomatic cellophane packing unit was designed, constructed, and tested. Results showed it increased a worker's rate of packing by 12.7 percent. The continuous blueberry harvester will be given extensive trials to determine fruit recovery, rate of travel, r.p.m. of spindles, amplitudes, and frequency of rotation, etc. An attachment for the packing unit which will automatically place the pint box in position has been designed and constructed and will be tested in a commercial operation.

From one-third to one-half of the gross returns of both sweet and sour cherries are paid to the workers who harvest the crop by hand. These workers are becoming increasingly hard to recruit--a situation which exists in all cherry-producing areas. The purpose of the research is to reduce the harvest costs and labor requirements through mechanization. An inertia shaker was designed and constructed and tested for harvesting cherries. Results showed that this type shaker recovers a higher percentage of the fruit, transmits more shake to the tree, and is more maneuverable than boom type shakers. A set of self-propelled low-profile frames was designed, constructed, and tested. Preliminary tests showed that decelerator strips are necessary over conveyors and desirable over deflecting surfaces, that slopes should be kept to a minimum if excessive bruising is to be prevented. Data again showed labor savings of over \$50 per hour and a variation of quality grades from excellent (over 95) to poor (under 80) depending upon the operation and equipment used. Instrumentation and apparatus were developed for evaluating cushioning materials and for studying velocities and bruising of falling fruit. This equipment consists of a 23-foot tube, lamps and photocells for measuring velocities, strain gages for measuring impact forces, two amplifiers, and recording equipment.

Extensive trials with chemicals for loosening sweet cherries showed that the chemicals tested were unsatisfactory. However, results indicate that sweet cherries allowed to reach full maturity increase in size and weight by 31 percent, that they can be harvested by shaking, and that it may be possible to brine them. The possibility of harvesting cherries for brining outlets at full maturity will be investigated in more detail.

About 225,000 tons of Concord grapes are produced each year in the six states of New York, Michigan, Washington, Pennsylvania, Arkansas, and Ohio. Conventional harvesting and handling methods are expensive and cause considerable damage to the raw product. Seven types of bulk boxes for handling grapes were designed and constructed:

(1) nailed wood, (2) plywood, (3) black iron, (4) stainless steel, (5) galvanized iron, (6) black iron painted with enamel, and (7) black iron coated with plastic. All boxes contain a hinged door for emptying. A dumper was also designed for emptying the boxes. However, due to the very short grape crop during 1961 in Michigan, commercial bulk box handling trials were not made. An automatic box-pick-up unit was designed, constructed, and mounted on a tractor.

This unit picks up boxes and elevates them to a trailer which is pulled behind the tractor. Preliminary trials of the unit are very encouraging. The box-pick-up unit will be field tested and if it shows real promise, it will be used in a commercial operation and time and cost data obtained.

The possibility of harvesting prunes mechanically in the California Coastal (Santa Clara Valley) growing area was studied. In this area the prunes fall to the ground when abscission of the stem forms at maturity. This presents a risk for a catching frame operation, as a high percentage of windfalls could occur which would have to be picked up by hand. The studies, therefore, were conducted to determine the feasibility of using catching frames and mechanical shakers (like those used in the Sacramento Valley) as a method of harvest. Three different methods of shaking were used--(1) trunk-circular, (2) trunk-linear, and (3) limb-linear--in the two different orchards. The tests indicated that mechanical shaking can be selective in the Coastal areas by shaking lightly the first time through. A large difference in the amount of windfalls between the two orchards was evidenced (10 percent of the total crop in one case and 22 percent in the other). This shows the degree of risk that would be involved in using catching frames. Depending on yearly conditions, any one grower might be successful one year and not the next. Based on the experiences and conditions of this year's tests, it seems that in order to assure a successful harvest every year, a pick-up operation or a blower-catch operation to cover a large acreage quickly is essential. In the Sacramento Valley an estimated 25 to 30 percent of the prunes were harvested mechanically and handled in bulk containers. Horsepower requirements for shaking were determined and results are being analyzed. An orbital trunk shaker was designed, constructed, and tested. Results showed the trunk-type shaker removed five percent less fruit than limb shakers.

Clingstone peaches and apricots. Hand labor for harvesting tender flesh fruits has become difficult to recruit. The possibility of selective harvesting with shakers and the effect of fruit injury were studied. On apricots a degree of selectivity was attained using an inertia shaker, with the best results at frequencies of 250 to 400 c.p.m. and about 1 3/4-inch stroke. On Clingstone peaches selective harvest by mechanical shakers is possible to a degree but it is felt not to be satisfactory for commercial operation. Results indicated that the best procedures for mechanical harvesting of cling peaches are (1) one-through harvest (all trees and fruit harvested), (2) two-time through harvest where only mature trees are harvested. Studies also showed that it is essential that decelerator strips and proper padding be used on catching frames if a minimum of fruit injury is to be expected. This padding must be of sufficient thickness to remove the energy from the fruit without causing excessive stresses. For average conditions, 3/4-inch sponge rubber, 1/2-inch ethafoam, and 1 3/4-inch foam plastic seem to be effective.

Mechanical thinning of peaches. Red Haven peaches were thinned with a boom type tree shaker at two orchards. Counts were made of the number of peaches on branches in different parts of the tree before thinning, immediately after thinning, and approximately one week later. At harvest the number, size, and weight of the fruit was obtained. Bark damage was studied. All data was taken on hand-thinned, machine-thinned, and a combination of hand- and machine-thinned trees. Results showed the thinning was random--no difference between tops and bottoms, that satisfactory thinning was obtained and mechanical thinning saves about 50 cents per tree.

Past attempts at mechanization of date harvesting have been concerned mostly with developing picking aids rather than mechanical removal of fruit. Time studies showed that 60 percent of the time of a worker was spent in actual hand-picking. Maturity studies indicated that it was possible to harvest bunches instead of individual ripe dates. Studies also showed dates could be handled in bulk boxes 18 inches deep instead of small lugs. Two types of equipment were designed and developed for separating dates from bunches which have been removed from the tree. Both vertical shaking and stripping tines look promising.

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II. UTILIZATION RESEARCH AND DEVELOPMENT

PROCESSING AND PRODUCTS

Western Utilization Research & Development Div., ARS

Problem. Fruits and nuts are valued for their unique flavor and color, and natural vitamin content. In the period of abundance at harvest time, markets are glutted and growers often do not get an adequate return for the effort and cost of production. Crops are perishable and processing to preserve their unique qualities is difficult. No processed fruit retains completely the fresh values although many highly acceptable products exist and about half of the fruits and nuts marketed in the United States are processed. This literally makes these commodities available to consumers the year around, and has opened new markets for producers. The proportion of processed commodities is steadily increasing but is dependent upon a continuing flow of new knowledge. Processing to preserve color, flavor, and texture of the raw material presents many problems generally, and each new product requires the application of much scientific and technological skill.

The freezing process for preserving certain fruits provides an excellent means for keeping the products at near fresh fruit condition. In spite of the gains in quality realized in freezing, many unsolved problems remain. The enzymatic browning of frozen peaches and the sloppy texture of frozen strawberries on thawing are two good examples.

Frozen fruits require expensive low-temperature storage and transportation facilities. The expense is greatly reduced by removing a portion of the water from the products. Examples of products developed on this principle are orange and other fruit juice concentrates which are well established in U.S. markets, and dehydrofrozen apple slices (rapid drying to 50% bulk weight and then freezing) which are just becoming well established. Many other fruits and fruit juices should be amenable to this type of processing and work on this is needed. Products of this type, however, are not so well adapted for export as those which do not require refrigeration.

The maximum weight reduction can be achieved through dehydration. The drying of fruit juices has been successfully accomplished by the vacuum puff drying and foam-mat drying processes. The latter process is under intensive study, because it can be carried out at atmospheric pressure and consequently offers a potential economy in processing. This process must be worked out in detail for many, as yet untried, fruit purees and juices and on pilot-plant scale for those products that show promise. Flavor recovery and the incorporation of recovered flavor in solid carriers for addition to the dried products are problems requiring technological and basic chemical

study. Essence recovery techniques developed for fruit juice concentrates are not completely satisfactory for this purpose.

Dried fruits and canned fruits are currently widely used in the U.S. and abroad. The popularity of dried fruits overseas and in this country would be enhanced if stable, higher moisture dried fruits were available and if lower levels of sulfur dioxide could be used without loss of quality. Control of mold spoilage in high-moisture dried fruit requires effective antimycotic agents.

Container costs for canned fruits limit considerably the shipment of these products overseas. A solution of the container problem is needed and may be found in the use of lightweight fiber, foil, or plastic containers and aseptic filling procedures.

A pressing problem of fruit growers is the need for new varieties of tree fruits and berries suited to processing and resistant to diseases endemic to each region of production. Utilization research is required in cooperation with farm research to assure growers of a market for fruit in the processing industry.

USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research on deciduous fruits and tree nuts is conducted at the Division headquarters at Albany, California, in field stations at Pasadena, California, Prosser and Puyallup, Washington, by contract in Honolulu, Hawaii, and by grant funds under P.L. 480 in Israel and Italy. Fundamental research is conducted on fruit constituents that are involved in the flavor, color, and texture of fruit products, and includes development of laboratory tools to isolate and characterize individual components, investigation of such components as they occur naturally and as they are altered by operations involved in preservation, and the relationships between the components and the product values being preserved. Applied research is conducted to develop new and improved processes and products that will increase the utilization of fruits and tree nuts, including the development of high quality concentrated and dehydrated products and more stable shelled tree nuts and the selection of improved processing varieties.

The Federal program of research in this area totals 28.5 professional man-years. Of this number, 10.7 are assigned to chemical composition and physical properties (including one employee whose salary is provided by the Dried Fruit Association of California); 2.4 to new and improved food products; and 15.4 to new and improved processing technology (including 0.5 professional man-years support for an employee whose salary is provided by the Dried Fruit Industry Research Advisory Committee, whose membership represents the California Raisin Advisory

Board, the Dried Fig Advisory Board, the California Prune Advisory Board, and the Dried Fruit Association of California and 0.5 professional man-years support for an employee whose salary is provided by the Diamond Walnut Growers, Inc.). In addition the Division sponsors 4.0 professional man-years of research under P.L. 480 including 1.0 on basic studies which are part of an investigation also concerned with vegetables, and 3.0 on applications of research findings.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 11.2 professional man-years divided among subheadings as follows: Chemical composition and physical properties 4.5, new and improved food products 2.2, new and improved processing technology 4.2, and new and improved industrial products and feeds from by-products of fruit processing (including waste disposal) 0.3. Fundamental studies are conducted on the components concerned with texture, color, and flavor properties of processed fruits and tree nuts. New fruit and fruit juice products and processes are concerned with novelty and convenience factors of importance in developing new markets. Blanching, freezing and dehydration processes are investigated. A fruit softening problem with brined cherries is studied cooperatively with Department of Agriculture scientists.

Industry and other organizations including food processors and distributors, industry and trade associations, and allied industries and suppliers conduct research programs that are predominantly concerned with specific applications to individual corporate problems. A portion of the research of processors involves the extension to commercial status of new processes of products that have been developed by the Department of Agriculture or other public or trade-sponsored agencies. A limited amount of oriented basic research is conducted by trade associations and the supplier trade, including sanitation in the food preservation industry, chemical residues and their toxicity limitations, packaging materials, and fundamental descriptions of raw materials used in food processing. Estimated annual expenditures in this area are equivalent to approximately 200 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Flavor Components. Of great importance to flavor chemistry in recent years has been the application of gas-liquid chromatography techniques. High instrument sensitivity was achieved by use of dual columns with dual-flame ionization detectors and programmed temperature control, so that it is now possible to separate and make tentative identifications of important volatile components from the

headspace atmosphere of a small flask containing only a gram or two of the food product under investigation. The procedure, developed at Albany, California is sufficiently distinctive to warrant a special name. The instrumental record developed by the new procedure is called an "aromagram." Earlier extraction and concentration procedures are not required so that possibility of introducing artifacts is minimized. Sample size required is very small and food samples can be withdrawn from processing lines at different stages or from packages during storage experience and analyzed for compositional changes that may be correlated with subjective evaluations of products. The aromagram procedure is more sensitive by a factor of ten than any method previously used. However, while this is below the sensory threshold of many flavor components, it is not sensitive enough to detect some odorous compounds at levels detectable by the human nose. Only a beginning has been made in using the aromagram in fundamental studies of fruit flavor. Characteristic differences in composition of storage-deteriorated frozen strawberries from those stored at protective low temperatures have been observed. Further applications of the aromagram procedure to raw material quality control for processing, changes induced by processing, and storage deterioration of processed products have been initiated. Developments are continuing to increase even further the sensitivity of equipment to measure flavor components.

2. Pigments. The preservation of natural fruit color is frequently a most difficult accomplishment. Generally, pigments are altered by processes used or degraded during subsequent storage of the product. The anthocyanins (reds, blues, purples, etc.) are sensitive to acidity changes and, in the naturally acid fruits, they tend to be bleached or adversely modified during heat treatments and during subsequent storage of processed products. Chemical structure and the nature of instability of anthocyanins have been studied. Natural and synthetic anthocyanidins have been prepared in which one or more of the hydroxyl groups have been stabilized by methylation. Thus, the principal locus of instability in natural red pigments has been detected. By methylation of the 3-position hydroxyl on pelargonidin, a bright red color was retained for two weeks whereas the unaltered compound was decolorized in two hours by sulfur dioxide. The chemical structural changes of such pigments with pH change has been rigorously investigated. It was found that at pH 3 to 4, one of the ring structures opens to give the corresponding, almost colorless, chalcone. Ring-opening is not favored if the compound contains a methoxyl or glycosidoxyl grouping at position 3. This clear understanding of the nature of the instability of this type pigment could lead to important applications to reinforce the natural red pigments of fruit juices, preserve the natural color of canned fruits, and restore the natural color of fruits, such as cherries which have been decolorized during the preserving process. Preliminary investigations on such applications have been initiated. In addition, the yellow pigments (carotenoids) of Thompson seedless grapes, Italian prunes, cranberries, blueberries,

blackberries, and black figs have been under intensive investigation. These pigments also have important roles in the color quality of processed fruits.

3. Enzymatic Browning. More effective ways are sought to prevent the brown discolorations of fruit caused by chemical reactions catalyzed by naturally occurring enzymes. The fundamental approach to this objective has been to understand the chemistry of chlorogenic acid (the principal substrate of the enzymic browning) and find methods for altering this and similar substrates. The action of a bacterial species (Pseudomonas fluorescence) degrades chlorogenic acid to non-browning components. Further investigation led to use of purified liver enzyme (transmethylase) to modify the darkening components in apples to prevent discoloration, and then it was discovered that natural enzymes occurring in apples would accomplish the chemical modification if conditions were adjusted properly. Thus, it is possible to adjust the pH of apple slices to 8.0, allow the enzymatic transformation to take place, adjust back to a normal pH, and obtain an apple slice that is not subject to enzymatic discoloration. Other fruits and vegetables exhibiting enzymatic darkening are being introduced into such investigations in searching for further applications. Furthermore, the extension of this procedure for apples to commercial operations is being explored.

4. The Chemistry of SO₂ in Dried Fruit. Several of the dried fruits are treated with sulfite (SO₂) in order to preserve prime quality and stabilize vitamins A and C. In subsequent storage of these products, the sulfite level drops, and in long shipments and harvest-to-harvest storage it may drop below the effective level. Furthermore, for export shipments, a high initial level may be required to allow for the exigencies of the marketing operation. In several of our important overseas markets, limitations on the level of sulfite are restrictive and it is necessary to learn more than is now known about the fate and mode of action of sulfite so that its use can be improved or alternative methods can be developed to retard deterioration in these products (pears, apricots, golden raisins, apples, and peaches). The main pathway for sulfite loss has been found to be oxidation to sulfate, and much of the loss occurs in the dehydration or sun-drying of fruit. Light accelerates the oxidation so that certain dehydrated products (particularly apricots) will retain sulfite better than sun-dried products. The better retention can be equated to lower required concentration of sulfite. It is not possible to achieve the sun-dried quality by conventional dehydration although a new procedure is being developed that shows excellent promise (paragraph C,2, of this report). Effects of storage temperature, humidity, and type of packaging for dried fruits on the retention of sulfite are being studied. In general, high temperature, high humidity, and transparency of package are associated with high sulfite disappearance rate. Sulfite acts in the role of an antioxidant in

preventing non-enzymatic browning in dried fruits. It may also have other modes of action, as in the bleaching of anthocyanin pigments, complexing with reactive sugars, and the control of enzymatic discolorations. These functions of sulfite are being investigated.

5. Texture of Fruits. Little is known of the enzymes involved in the formation of cell wall polysaccharides of plant tissue. This, in part, is due to the dearth of knowledge of the cell wall constituents themselves. Work in this complex field has been initiated, using an enzyme preparation obtained from germinating mung beans. By use of radioactive tracer techniques, the enzyme preparation was found capable of forming two polysaccharides from glucose and fructose. One of the polysaccharides was soluble in hot water, the other not. The former is apparently formed by a previously unrecognized enzymic pathway with the glucose incorporated into the polysaccharide, intact. This polysaccharide is unusually resistant to acid hydrolysis. This study has further offered a clear insight into the nature of an alternative pathway of glucose metabolism bringing a new enlightenment to the way higher plants utilize carbon sources for cell wall synthesis.

6. Ascorbic Acid Biosynthesis in Plants. L-ascorbic acid (Vitamin C) occurs in all higher plants but little is known of its biosynthetic origin, its function, or the nature of its accumulation in fruits and vegetables. The enzymes involved in these processes are being studied by radiotracer techniques in which precursors of ascorbic acid are labeled with C^{14} and fed to living plant tissue. Ascorbic acid, later isolated from the plant, demonstrates by the amount and pattern of its radioactivity the pathways by which the vitamin is formed. It has been proven that glucose is converted, in strawberries, to ascorbic acid and not to an isomer, D-arabo-ascorbic acid as suggested by other researches. The net result of this has been to demonstrate that plants possess the astonishing capacity to convert a D-sugar to L-ascorbic acid by changing the configuration about a single carbon atom. Interrelationships are being elucidated among glucose, galacturonic acid (the main building block of pectins and important in textural quality of fruits), methyl ester of galacturonic acid (an important compound in the textural quality of fruits), and ascorbic acid. The methyl ester of galacturonic acid is a better precursor of ascorbic acid than is the acid itself. On the other hand, both the acid and its ester function in pectin synthesis and both undergo reduction to the same compound, galactonic acid.

7. Chemical Attractant for Fruit Flies. Drosophila (vinegar fly, fruit fly) is a serious pest in the fruit processing industries. When infestations are high in orchards and vineyards and around processing plants, it becomes difficult to pack products substantially free of insect fragments and eggs. Insecticide sprays now in use are difficult to control so as to avoid inadvertent residues in

products, and processors would prefer to use baited traps or other means of control if such were effective. A cooperative project between the Western Utilization Research and Development Division and the Entomology Research Division was conducted to explore the chemistry of possible attractants for Drosophila and to develop better baits for the fly. Preliminary studies were only partially successful and the project has been terminated for the present time. Juices and purees from ten different fruits (strawberry, Scarlet grape, Thompson grape, Italian prune, French prune, apple, peach, Mission fig, Kadota fig, and Bartlett pear) were fermented under various conditions and times and the products of fermentation were separated. These products were subjected to screening as attractants for adult Drosophila by the Entomology Research Division, Beltsville, Maryland. About 1,000 samples were tested. None of these proved to be as attractive as the yeast-sugar-water-vinegar mixture used as the standard lure. Nor were trends noted which suggested concentrating effort on particular fractions.

A commercial product has been placed on the market and is understood to be an effective bait and poison for Drosophila control. In view of the availability of a commercial, effective attractant and of the absence of promising leads from the work already done, this project was discontinued.

8. Preservatives for Dried Fruit. Present market practice involves a tenderizing treatment for retail packs of dried fruit. Prunes, figs, and dates are sold at moisture contents that will allow growth of mold and yeasts unless preservatives are added. The industry has depended upon ethylene and propylene oxides as antimycotics but the 1958 amendment to the Pure Food and Drug Act required proof of non-toxicity of residues from such treatments. Methyl and ethyl formates, used mostly for insect control in raisins, also require clearance. Pharmacological tests were conducted, supported in part by the dried fruit industry who provided the salary of a collaborator, to determine the toxicity information necessary for clearance of these preservatives by the Food and Drug Administration. Propylene oxide and methyl formate have now been approved for use as preservatives for dried fruits. Studies on ethylene oxide are nearly completed, and approval will depend largely on the legal interpretation of the Delaney Clause of the Food Additive Amendment. This clause rules out additives whose use in any proportion in animal diets can cause cancer. Ethylene oxide has not been demonstrated to be carcinogenic but, when fed in large quantities, can cause oxalate stones in rat bladders. The irritation of the stones has led to bladder tumors in the experimental animals. Thus, at levels below which stones would be caused, ethylene oxide could not cause cancer and should be cleared. Because of the secondary effect at high levels in the diet, it remains to be decided whether ethylene oxide will be allowable as an additive to dried fruits under the Delaney Clause. As described

elsewhere (paragraph C,3, this report) another antimycotic has been found effective for dried fruit and the industry problem is now largely resolved. Investigations on the toxicity of preservatives for dried fruit will soon be completed and the industry support may be transferred to other critical problems in the processing of dried fruits.

9. Microbial Flora in Fruits and Vegetables. Fundamental studies on microbial flora within the tissues of fruits and vegetables have been conducted under P.L. 480 in the Department of Food Technology, Agricultural Research Station of the Ministry of Agriculture, Rehovot, Israel. Fruits have been found containing viable micro-organisms within the tissues. It is probable that these organisms gained entry during the formation of the fruit on the plant, but this has not been conclusively demonstrated or proven. Samples studied included grapes and olives and, also, grapefruit and orange. Bacteria of the Xanthomonas, Pseudomonas, Enterobacteria, and Corynebacteria groups have been found, as have yeasts of the Nematospora. Such entrapped micro-organisms can make only a limited development and grow rapidly only when the tissue has been disturbed by injury or maceration. The relationship of such adventitious microbes to processing quality of fruits has not been revealed by these studies and may not yield itself to techniques that are currently available.

10. Enzymes Involved in the Ripening of Fruits with Ethylene. The effects of ethylene gas on maturation rates of harvested fruits in storage have been known for some time. The knowledge has served as a basis for controlled ripening of lemons and bananas, and accumulation of ethylene has an adverse effect on fruits to be held for long periods in cold stores. Basic research is under way to learn the biochemical nature of the ethylene effect on maturation of fruits so that its function can be better controlled and made more useful. The avocado was selected as an example fruit to study because it is available the year around, is a good producer of ethylene, and has a strong response to ethylene treatment. Avocados are exposed during maturation to ethylene synthesized with radioactive carbon or hydrogen. The labeled ethylene reacts in the maturing fruit and analyses are made to determine the reaction products. When avocados were ripened in the presence of hydrogen-labeled ethylene, 15% of the label was found in the hydrocarbon, toluene. The establishment of this hydrocarbon as a major reaction product indicates an unusual, perhaps unique, metabolic pathway involved in maturation.

B. New and Improved Food Products

1. Fruit Powders. Preliminary work with the newly developed foam-mat drying technique has demonstrated the possibility of producing powders from applesauce, peach, pear, and apricot nectars, pineapple juice, berry products, Concord and wine grape juices, prune puree and whip, and plum puree. Enzymic flavor release methods have been studied to seek the fuller development of fruit flavor in dried fruit powders. In preliminary studies with apples, volatiles were produced. This aspect of the product development will continue. Subjective evaluations of products are conducted to seek improved quality, particularly improved flavor of products.

2. Dehydrofrozen Fruit. Laboratory studies are completed on the development of processes to partially dry fruits and preserve them by freezing. Extensive commercial operations now exist in the upstate New York area (estimated production in excess of 8,000,000 pounds of product per year of dehydrofrozen apples for the bakery trade). During this reporting period, cooperative work has been conducted with several processors and with the New York Agricultural Experiment Station to adapt processes developed with Western grown fruits to local varieties and to adapt processes to the different types of equipment installed in the plants. Interest in dehydrofreezing cherries is high and technical problems are still under investigation. The Albany, California staff will continue to cooperate with the Experiment Station and industry in further extension of this technology but no laboratory research is contemplated.

3. Processing Quality of Northwest Soft Fruit and Berry Varieties. Canning, freezing, and preserving of new and improved berry and tree fruit varieties have continued in field stations at Prosser and Puyallup, Washington in cooperation with horticulturists of the Washington State Agricultural Experiment Station. Selection of varieties to resist disease and improve yields is a task without end. Processing quality must also be considered for most fruits, because an increasing proportion of the harvest is preserved by one means or another. (About 90 percent of Northwest strawberries are processed.) Decreasing production of the Marshall strawberry has emphasized the need for a new variety, with good quality for jam and preserves. Processing studies at Puyallup have helped establish the Cascade variety for this purpose. Incursions of root-rot in raspberry plots have emphasized the need for resistant varieties. Expansion in blueberry and rhubarb production depends on improved varieties and processes and new products to build new markets. Strawberries with a growth habit that will make them easier to pick and thus reduce harvest labor costs are becoming more needed as each year passes. Apricots, peaches, and plums with better texture, flavor, and color and with different maturation character to extend the harvest season

are needed. Processing aspects of quick-decline-affected pear orchards may have important economic impact. These problems are subject to continuing investigation in cooperative studies. Each harvest season, new varieties are processed as well as the standard commercial varieties, with which they are compared. Several years and many replicated plots are required to establish the value of a new variety under varied conditions and make a fair comparison with the established varieties. Then, after careful evaluation the horticulturists may release a very small fraction of the numerous trials, with a complete statement, including the processing character for various uses (canned, frozen, juice products, and preserves).

4. Maturity Index for Harvesting Fruit. An index to measure maturity is necessary for many fruits if prime raw material is to be available for processing. Control of quality of processed products starts with the quality of the raw fruit and optimum development of color, flavor, and texture on the tree is very important. Soluble solids and acid measurements have not provided adequate indexes for some fruits. Fresh fruit color for purple plums and dark sweet cherries appears to be a more useful index of when the fruit should be picked but visual examination of color is not accurate enough to be depended upon. The optical density of an extract of sample fruit can be accurately measured with readily available colorimeters and has been found to be the basis for predetermining the color of canned fruit. Extension of this new maturity index to commercial canning operations is beginning and is expected to provide improved products for marketing these fruits.

5. Canned Concentrated Peach and Apricot Purees. Studies on the effects of temperature and temperature variations encountered in transportation and distribution of concentrated peach and apricot purees as a basis for improving processing conditions have been conducted under a P.L. 480 grant to the Experiment Station for the Food-Preserving Industries, Parma, Italy. Extensive analyses and evaluations of color, flavor, aroma, sugars, nitrogenous constituents, volatile and non-volatile acids, and vitamins have been conducted, comparing single strength and concentrated purees. Processing effects have been observed related to the organoleptic values of products but concentration has been accomplished with no important change in nutritive components. This project will terminate soon.

C. New and Improved Processing Technology

1. Foam-mat Drying. Over 50 agricultural commodities have been successfully dehydrated by the foam-mat drying process invented by Department engineers at Albany, California. These include applesauce and juice, peach, pear, and apricot nectars, berry products,

Concord and wine grape juice, and prune puree and whip. Continuous, automatic equipment has been designed and constructed for continuing experimental studies. A commercial dryer of similar design has been installed in a food processing plant in California and several other industry applications of this novel dehydration method are being investigated with pilot operations to develop commercial-scale equipment. Most products tested can be dried at atmospheric pressures without off-flavor development or discoloration. There is a loss of volatile flavor components. A major problem in the technology of each product so dried is to find means for adding back or redevelopment of flavor. The enzymic release of volatile flavor from non-volatile precursors retained by dried apple products has shown promise in preliminary investigations. Solid carriers, such as sugar and other carbohydrates are used to "lock in" volatile flavor components and equipment has been designed to mix and form the carbohydrate-flavor mixture. This equipment operates continuously and has advantages over previous methods by minimizing heat requirements, thereby minimizing chemical alteration of the volatile flavor components. Improved foam stabilizers, required for some products in foam-mat drying have been selected or developed to improve product quality. Drying cycles have been determined for specific products to prevent serious quality loss during processing and to increase heat and moisture transfer and mechanical efficiencies so that processing costs may be reduced.

2. Dried Fruit Processes. Problems encountered in the conventional sun-drying of fruits include occasional product losses due to inclement weather and contamination during field exposure. Sun-drying of cut fruits produces a desirable translucency in the product and is the lowest cost method. If the quality factors could be made equal, many producers of dried fruit would welcome a dehydration procedure that would be used when conditions beyond their control force them to curtail sun-drying operations. An improved process, called "Dry-Blanch-Dry" or "DBD" has been developed in which dehydrated apricots, peaches, pears, and raisins have been produced with "sun-dried" quality. Commercial trials were run comparing DBD with sun-dried apricots and subsequent stability tests made of the two products. An important extra credit for the new process was observed in that sulfur dioxide disappearance rate from the product was lower for the DBD. This suggests the possibility of using somewhat reduced sulfur dioxide levels to achieve the same stability, a factor of importance in exportation of dried fruit because some countries restrict the amount of this stabilizing additive to levels where product quality may be jeopardized in the long channels of trade. The DBD process involves a partial drying of the prepared fruit, followed by steam blanching and finish drying. With apricots, peaches, and pears, the halved, pitted fruit is sulfured as with sun-drying prior to the first drying step. In addition, bin-drying procedures for the final moisture removal (from 16% down to

12%) from cap-stemmed muscat raisins were established in pilot operations. Equipment cost savings of over 50% by using bin-drying instead of conveyor-belt dryers are estimated.

3. Stabilizing Dried Fruit. Research on procedures for stabilizing dried fruits is conducted with support of the Dried Fruit Association, which provides the salary of a scientist assigned to this project. Critical studies of the effects of temperature, humidity, exposure to light, and moisture content on the stability of prunes, figs, dates, apricots, and apples have been completed. Methods for determining product moisture content were evaluated, and suitably reproducible methods were established for use in this investigation. The question of permissibility of ethylene and propylene oxides as antimycotic agents for tenderized prunes and figs led to a search among additives already cleared for food use by the Food and Drug Administration. A process was developed to apply potassium sorbate by spraying a water solution. Spray-treated, high-moisture prunes and figs resisted microbial spoilage and this process is now standard in the industry with all but one major dried fruit producer using it. Approximately 70,000 tons of dried figs and prunes are given this treatment annually. A necessary analytical method for determining sorbic acid and sorbates in dried fruits was developed. Two additional processes relating to this study were developed in the laboratory and are undergoing trials to determine commercial applicability. First, a novel method for rehydrating dried fruits for tenderizing. Dried fruit pieces are heated in steam and then dipped in cold water, which induces remarkably rapid imbibition of water. Second, a simple heat treatment was discovered to prevent the "setting up" of ground-up raisins (raisin paste--a product used in the baking trade). The ground-up product is held at 120° F. for 2 days and it will then remain spreadable and of a satisfactory consistency for remanufacturing use. Without the mild heat treatment the product must be reground to be used.

4. Wax-coating Raisins. When raisins are added to breakfast foods or similar products, the dry cereal ingredients draw moisture from the raisins making them hard and unattractive. For such products to retain quality long enough for orderly marketing, a barrier must be used to reduce the rate of moisture transfer. Beeswax is a suitable barrier but difficulty has been encountered in the past in applying it so as to have a uniform, continuous coating and, at the same time, reduce the amount added to an economical level--about 2-1/2% by weight of wax, or less. A machine capable of applying such a thin coating of beeswax has been designed and constructed. Preliminary tests indicate that the machine will do an exceptionally good job with wax contents ranging from 2% for large raisins to 2-1/2% for small raisins. Such coatings are effective in slowing the moisture loss from raisins, are not objectionable from a flavor standpoint,

and are in the economical range specified by the breakfast cereal industry. Commercial trials of the new equipment are being conducted.

5. Softening of Brined Cherries. Occasional outbreaks of a serious softening condition of brined cherries has plagued the fruit industry of the Northwest. Cooperative studies have been conducted with the Oregon and Washington Agricultural Experiment Stations to determine the cause of such outbreaks and to develop methods for control. Studies of natural fruit enzymes and enzymes produced by micro-organisms were studied in regard to softening. Modifications of brine formulas and use of various additives were also investigated. Using laboratory procedures in which softening was induced in sound cherries, a number of tentative factors were established including the inhibitory effect of calcium, and the softening effect of a number of fungi inoculum. Brined cherries to which pectin-splitting polygalacturonase had been added softened, yet naturally softening cherries have been observed in which this enzyme could not be detected. Treatments that have been effective in laboratory tests, including excess calcium salts and one of the common detergents, have not been effective in controlling softening in a commercial sample of cherries undergoing deterioration. Heating the fruit and brine to pasteurization temperatures has so far been an effective method of control. Although the problem of brined cherry softening has not been resolved, the texture testing procedures developed as necessary for the conduct of research, have been picked up by the industry as a useful quality control tool to provide advanced indication of a softening "infection" in commercial operations.

6. Stabilizing Shelled Nuts. Shelled tree nuts are a convenient food item, but they tend to darken and turn rancid rather quickly. An investigation of factors involved is supported, in part, by the Diamond Walnut Growers, Incorporated, which supplies the salary of one chemist assigned to the field station at Pasadena, California. Previous work at Pasadena resulted in a process that has had extensive commercial use--stabilization was achieved by critical control of moisture content, coating the kernels with antioxidants, and sealing in a package of transparent film with a very high moisture barrier rating. Less expensive packaging is required to maintain shelled nuts in a more attractive competitive position. Chemical and technological studies are in progress with walnuts to determine the constituents involved in dark discoloration and oxidative rancidity development and to develop methods of controlling the deleterious effects. Constituents are identified and changes they undergo under various conditions of temperature, light, and atmospheric gas are measured. Correlations of constituents with discoloration and rancidity development are being developed. A project along similar lines, but with macadamia nuts, has been initiated under contract with the University of Hawaii. Macadamia nuts appear to

to be a useful crop to replace acreage of pineapples, in excess production, and coffee, a product in some distress because of high production costs and difficult quality controls.

7. Northwest Grape Juice. Processing of Concord grape juice and the effects of cultural practices on composition and quality of juice are under cooperative investigation in Prosser, Washington with the State Agricultural Experiment Station. Organoleptic quality of this grape juice has been determined to be most closely related to the soluble solids and acid content. Over a substantial range of difference in naturally occurring methyl anthranilate (considered to be the principal flavor component of Concord grapes) flavor differences were not detected. Juices from high and low soluble solids grapes could not be distinguished from each other after adjustment to the same soluble solids and acid content. This indicates that cultural practices giving maximum yield can be used even at the expense of producing grapes of lower soluble solids. Low solids content would have no effect on product quality in juices packed as frozen concentrate because refined sugar and acid are added during processing to such concentrates in any case. Furthermore, Concord grapes were found to tolerate a rather wide range of heat treatments during extraction and processing without appreciable alteration of flavor. Thus, in commercial operations it is possible to make considerable adjustment to provide better extraction of color and flavor components.

8. Fouling of Heat Transfer Surfaces. Fundamental engineering studies were conducted on the nature of fouling of heat transfer surfaces in evaporators used in the concentration of fruit juices and purees. Fouling was increased by increasing surface temperature, vapor fraction in the tubes, and product viscosity. Furthermore, fouling was markedly more rapid when products were being warmed compared to when they were being boiled. A resistance-impedance thermometer concept was developed to obtain accurate surface temperature and related heat transfer measurements. This can be extended generally to heat transfer investigations and operations control in the field of temperature-sensitive fluids. Observations of this research lead to conclusions that can influence design and use of evaporators. Studies have been initiated to determine the feasibility of such applications. For example, it could be predicted that vapor fraction would be reduced by using upflow instead of downflow in an evaporator tube. Experimental work confirmed this prediction and, within the practical operating range studied, upflow resulted in only half the fouling rate of downflow. Studies of fouling in tubes for warming liquids have not been conclusive yet because of difficulties in measuring true liquid temperature at various points in the test system. A new electrical warming system has been designed to replace the steam heat source. Voltage drop in the system can be measured

to represent heat liberated and the average liquid temperature calculated by heat balance. Fouling data to guide design of long-tube evaporators is thus being obtained.

9. Continuous Juice Press. A new, larger, but still experimental continuous press was successfully plant tested as a preliminary dejuicer during the 1960 season. When operated on firm apples such as Newtown Pippins, the 5' x 1' machine had a capacity of a little over 6 tons an hour, for a gross juice yield of about 150 gallons per ton of fruit. With ripe, mealy Red Delicious apples the capacity dropped to about 4 tons an hour, with a gross yield of approximately 120 gallons per ton. Secondary pressing is essential for yields comparable to those obtained in a good rack-and-cloth operation (170-180 gallons per ton). Attempts were made to use a screw press for this purpose. The repressing operation was successful only when a substantial amount of wood pulp was added to the ground fruit--about 3/4 of 1% by weight for firm fruit; 1-1/2% for ripe fruit. Combined juice yield from the two machines was about 180 gallons per ton, a figure competitive with most rack-and-cloth operations. Net yield, after Pectinol treatment, was about 145-150 gallons per ton, compared with 158-162 gallons per ton for the rack-and-cloth press. Observations were made of commercial attempts to produce apple juice of adequate yield and freedom from suspended solids. Although some equipment did a fairly good job when apples were in the right condition, results were not so good when the raw material quality changed as it will inevitably do during the storage season. A conclusion was reached that more basic knowledge of the pressing characteristics and processing requirements of apples of different varieties, maturities, and composition is needed to serve as a basis for further developmental work on a practical continuous dejuicing system.

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PROCESSING AND PRODUCTS
Eastern Utilization Research and Development Div., ARS

Problem. Lack of knowledge of the nature and quantities of the various chemical constituents and enzyme systems present in fresh fruits, and of the changes these undergo during processing, is a limiting factor in research designed to develop new and improved products and processing techniques. Knowledge is required on the composition and physical structure of fruits and fruit products, with emphasis on substances responsible for color and flavor, vitamins, and other constituents important in determining consumer acceptance and nutritive value of the products. Composition should be studied in relation to variety, stage of maturity, and environmental conditions of growth; and to changes occurring between harvesting and processing, during processing, and in storage and distribution. Recently developed equipment and techniques have made it possible to isolate, separate, and identify constituents that could not have been handled previously. As basic information is developed, new processing techniques will be applied in the improvement of fruit products, the development of new fruit products, and in more efficient utilization of by-products from fruit processing.

USDA PROGRAM

The Department has a continuing long-term program involving chemists, biochemists, and chemical engineers engaged in both basic and applied research related to extending the use of fruits in the food processing industries. In the EU program, apple products research, and investigations on the chemistry and cell structure of cherries are conducted at Wyndmoor, Pa. Development of rapidly-reconstitutible dehydrated fruit pieces is also underway at Wyndmoor. Contract research on peaches is in progress at Rutgers University, New Brunswick, and on apple texture at the Maryland Agricultural Experiment Station, College Park. The Federal (EU) scientific effort devoted to research in this area totals 9.7 professional man-years. Of this total, research on chemical composition and physical properties constitutes 6.0 p.m.y.

Research on new and improved food products amounts to 2.3 p.m.y. including 0.3 p.m.y. of contract research on apple texture at the Maryland Station. During the year, contract research on the use of fruit essences and concentrates in frozen desserts at the Maryland Station was terminated. Research on new and improved processing technology amounts to 1.4 p.m.y., including 0.4 p.m.y. of contract research on peach processing at Rutgers.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Related programs of all State Experiment Stations and industry and

other organizations is reported by the Western Utilization Research and Development Division in that Division's Summary of Current Program and Preliminary Report of Progress.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemistry and Cell Structure of Cherries for Processing. Previous work on this subject has been concerned with (a) composition of cherries as affected by bruising and aging prior to canning and (b) influence of harvesting methods on quality of red tart cherries (in cooperation with the Agricultural Engineering Research Division). It was established that no sharp change in respiratory activity occurs as cherries mature, which means that harvesting may be spread over a relatively long period with very little physiological change or quality impairment. Some bruising inevitably occurs during cherry picking and handling. It has been found that the firming which takes place when raw cherries stand at orchard temperature for several hours between harvesting and canning is accompanied by conversion of a portion of the pectin to pectic acid by demethylation. The pectic acid may be responsible for the more rigid cell walls of the firmer fruit. An additional discovery was that techniques employing radioactive carbon 14 can be used to study the effects of harvesting and postharvesting practices on the fruit quality.

Mechanical harvesting of cherries has been practiced only for the past two seasons to any appreciable extent. This research has led to improvements in the type of shaker used and in decelerating the fall of the cherries into the catching net by use of 6-inch wide ribbons. Wide adoption of mechanical harvesting of cherries will involve changes in processing methods, preprocessing treatments, equipment and grade standards all of which will require research.

2. Influence of Carbohydrates in Apple Texture. This contract research at the Maryland Agricultural Experiment Station has been concerned with the relation between the insoluble carbohydrates and the texture of raw and processed apples. York Imperial, Stayman and Golden Delicious varieties were harvested at four stages of maturity and fruit was removed from storage at 25, 50, 75 and 100% of the expected storage life. Apple sauce and canned slices were prepared from each treatment. It is indicated that starch content decreases and cellulose increases at maturity. While it is not yet possible to conclude what is the optimum, it seems that the ratio of starch to other polysaccharides may be useful as a guide for deciding the time of harvest and storage time of apples intended for processing. The softening of apples during storage appears to be due to changes in a starch-pectin complex. Quality control in apple processing by carbohydrate analysis seems to be a fertile field for additional investigations.

B. New and Improved Food Products

1. Rapidly-Reconstitutible Dried Fruit Pieces. A porous, rapidly-reconstitutible structure is imparted to partially dried fruit pieces, e.g. 3/4-inch apple cubes, by heating them above 100° C. in a puffing gun and then suddenly releasing the pressure. Drying of the porous pieces to a low moisture-content is then readily carried out by ordinary methods. The "instantized" dried apple pieces can be reconstituted to a compote by boiling one minute in water containing sugar, or they may be mixed with dry cereal to contribute a crisp apple component. The "instantizing" process, which is attracting much outside interest, is to be applied to blueberries and to other fruits.
2. Improved Apple Cider. In studies on the preservation of cider by sorbic acid it was discovered that hydroxymethylfurfural (HMF) is formed during heat treatment of cider. Pasteurized cider darkens on storage, with accompanying increase in HMF and sedimentation. Model systems have been used to study the role of HMF under a wide range of conditions. Subsequent work will be concerned with improvement of cider quality and development of new cider products through knowledge gained with these model systems.
3. Dried Apple Sauce. Since dried apple sauce (now made commercially by drying apple slices, grinding and adding sugar) provides good color and texture in the reconstituted product, the Quartermaster Corps procures this item in volume. The current product, though, is notably lacking in characteristic apple flavor. A taste panel definitely preferred reconstituted sauce with essence containing apple juice powder in comparison to sauce reconstituted from the unmodified product. The Quartermaster Corps now has this improved product under test.
4. Essences and Concentrates in Frozen Desserts. Studies on the use of fruit essences and full-flavor concentrates in supplementing fresh fruit in ice cream and other frozen desserts showed that a significant flavor improvement could be realized without impairing the body and texture of the frozen dessert. Formulas and cost data are now being made available to ice cream manufacturers and efforts are being exerted to secure commercial adoption.

C. New and Improved Processing Technology

1. Processing Characteristics of Eastern Peaches. More than 300 new strains of peaches are available from the breeding plots at the New Jersey Agricultural Experiment Station. These are to be screened to appraise their potential value for processing. Promising strains will later be more rigorously evaluated by a panel for color, flavor, and texture. It is hoped that one or more Eastern varieties of peaches can be developed that will can well and possibly also be good for fresh use. Work on this project began in June 1962.

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III. MARKETING RESEARCH

MARKET QUALITY

Market Quality Research Div., AMS

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Additional information is needed with respect to the accurate measurement of market quality and the effects that various handling practices and procedures have on the maintenance of quality. Objective measurements of quality would greatly assist in standardization and grading procedures and the development of instrumentation for this purpose greatly increases the chance for ultimate automatic quality sorting on a commercial basis. Additional information is needed on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Consistently safe and effective transportation of the more perishable fruits can be accomplished only by continued research with transportation equipment and services as affecting ultimate quality of the product in the market. Dried fruits are subject to insect infestation from the time they are being dried in the field until they reach the final consumer. There is need for research to develop more effective measures to prevent this infestation all along the line, as raisins are drying in the field, during storage while they await processing, in the processing plant, and after they are packaged. Research is also needed to develop effective measures for protecting tree nuts against insect infestation during storage and after packaging.

USDA PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, food technologists, chemists and entomologists. The research in horticulture includes both measurement of quality and maintenance of quality during the period between harvest and consumption. Locations include the headquarters laboratory at Beltsville, Maryland; field laboratories at Wenatchee, Washington; Fresno, California; and Raleigh, North Carolina; and market laboratories in Chicago, Illinois and New York City, and contract work at Corvallis, Oregon with the Oregon State Experiment Station. Also there is a continuing long-term program at Fresno, California, which involves entomologists in applied research on the prevention of insect infestation, damage, and contamination of dried fruit and tree nuts in marketing channels. The research is conducted in cooperation with California State and County agencies and with several industry groups. Basic and developmental studies at

Savannah, Georgia, involve entomologists and chemists whose research has cross-commodity applications. The entire program is discussed in Area 13. Although much of the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to dried fruits and tree nuts, only a proportional part of that effort has been allocated to Area 3.

Federal effort in this program totals about 18 professional man-years divided as follows: objective measurement of quality 2.0; quality maintenance in handling and packaging 1.5; quality maintenance in storage 3.4; quality maintenance during transportation 1.3; post-harvest physiology 1.8; post-harvest disease control 4.0; and prevention of insect infestation 4.8 man-years. This includes fractional man-year time on contract research, and about one man-year for leadership in the total area.

Work terminated during the period included: handling of McIntosh apples; packaging Western peaches; film liners for grapes; film liners for pears; thermostatic control of car temperatures; control of apple scald; bullseye rot of apples; control of decay in apples and pears; fiberboard boxes for apples; film liners for plums; brown core of Anjou pears; transportation of Bartlett pears; freezing injury to apples in transit; control of sweet cherry decay; control of soft scald of apples; control of decay in peaches for processing; storage of strawberry plants; quality measurement of peaches for processing; and residual sprays and good housekeeping to prevent insect infestation of dried fruit.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 16.6 professional man-years in this area. These were divided among quality measurement, packaging, storage and transportation studies and research on post-harvest physiology and diseases. Almost half of the research in market quality is shown for the western region with the balance of the program fairly evenly divided among the other regions of the country. No work was reported on insects infesting dried fruit and tree nuts. Industry and other organizations, principally chemical companies and dried fruit and wine companies, conduct limited research involving market quality of deciduous fruits and nuts. In 1961 this effort was estimated as about 7 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Eastern apples. A light transmittance instrument developed for evaluating maturity of apples on the basis of chlorophyll content was given an experimental trial during 1960 in a cooperating grower's packing shed. Several thousand apples of three sizes (Red Delicious and Golden Delicious varieties) were classified into three categories of apparent maturity on the basis of the readings of the instrument. External color difference between these categories were observable with Golden Delicious fruit, but not with Red Delicious.

This fruit then was stored and subjected to several quality determinations at intervals through the storage season, which was about 5 months for Golden Delicious and 8 months for Red Delicious. The laboratory taste panel consistently rated the fruit classed as most "mature" (low chlorophyll) by the instrument as being sweetest. The soluble solids content of this category of fruit was highest also.

The panel rated the Golden Delicious fruit classified as least "mature" (high chlorophyll) by the instrument as being the most acid, but observed no significant difference in acidity among maturity categories of Red Delicious. However, the data on titratable acidity showed no consistent relationship in either variety with maturity category as measured by the instrument. At time of harvest, firmness of all three categories was the same in each variety.

Two large scale taste panel evaluations of preference were made on Red Delicious after $7\frac{1}{2}$ months of storage. The first, made on fruit immediately out of storage indicated that the apples of the least mature category were least preferred. The second evaluation made on fruit held 3 days at room temperature showed no significant differences among the three categories.

After 8 months' storage, Red Delicious classified by the instrument as most mature had most break-down upon holding at room temperature.

The more mature Red Delicious had more water-core than the less mature categories. This is particularly significant since the light transmittance instrument provides a method for detecting this internal defect without cutting the fruit.

In 1961 weekly pickings of Red Delicious and Golden Delicious from young and old trees were separated by light transmittance readings into high, medium, and low chlorophyll, and stored at 32°F. After six months' storage, Golden Delicious fruit of high chlorophyll content

at mid-season harvest had only 1-2% rot as compared to 30% rot for low chlorophyll fruit harvested the same date.

After six months' storage, early-harvested, high-chlorophyll-content, Red Delicious apples had developed about 1% decay. Low-chlorophyll fruit harvested a few weeks later developed about 8% decay in the same period. After one week at room temperature, rots increased to about 4% and about 26%, respectively. Scald development in Red Delicious was most serious in the high chlorophyll fruit.

2. Western apples. A good correlation between light transmittance readings on the difference meter, specific gravity of the individual apples, and the severity of water core, as shown by examination of the cut fruit, was obtained with Starking Delicious and Winesap apples at time of harvest. Difference Meter readings on Starkings made at intervals during storage were consistently higher than at harvest and not reliable as an indication of water core, particularly as browning or discoloration of the flesh developed.

Initial readings of 60 or higher on size 88-125 Starking indicated apples free of water core. Progressively lower readings indicated increased severity of water core. In February, there was considerable browning of the flesh of the apples with initial difference meter readings indicating moderate water core. Most of the fruit with less initial water core had cleared up by February but examination of this fruit in March disclosed 50% breakdown. By May, even the Starkings which had started the storage season with the slightest water core had developed 20% breakdown.

Difference meter readings on Winesaps during storage were more indicative of the intensity of water core. Most of the water core in this variety cleared up without extensive flesh browning. The discoloration that did occur was confined in most cases to the core area.

A "Mechanical Thumb" for determining firmness of apples, which is not destructive to the fruit, was developed at Wenatchee as an attachment to the Magness-Taylor Pressure Tester. The apple tissue involved is about the same area and volume as that bruised by an inspector when he uses his thumb to test firmness so the fruit need not be discarded after testing.

3. Red tart cherries. Anthocyanin pigment development in sound, intact red cherries was evaluated by light transmittance techniques. This was accomplished by measuring the difference in optical density of 540-612 mμ. This value (Δ O.D. 540-612 mμ) correlated highly with the anthocyanin content of the cherries as determined by chemical procedures. However, this reading was affected by the condition of the cherries. Bruised fruit which was held until scalded gave higher readings than fresh, sound cherries. Further experiments indicated that it was

possible to detect and evaluate the extent of scald by light transmittance measurements at longer wavelengths (780 - 695 mu). It is necessary, however, that cherries be evaluated for this type of damage before measurement of their anthocyanin content. This might be done rapidly with a dual purpose instrument without damaging the fruit.

A light transmittance instrument of the direct phototube type was used to sort cherries for scald at $\Delta O.D.$ 740-695 mu and for red pigment development, $\Delta O.D.$ 620-540 mu. Good agreement was achieved between instrument sorted fruit and visual evaluation. Fruit sorted for red pigment were measured by category on a color reflectometer (Hunter CDM) then canned and processed. Low colored cherries (0-30 scale reading by light transmittance) read 126 by CDM color formula, while more highly colored fruit, classes 30-50 read 139, 50-70 read 149, 70-80 read 152, 80-90 read 156 and the highest colored cherries (90-100 scale reading) read 159. Soluble solids determined on representative samples of these lots were 11.6, 13.0, 13.5, 14.2, 15.9 and 16.7 percent, respectively, indicating an additional quality separation. The relationship of scald index and separation for color with fresh and processed product grade is being determined.

An extensive program was undertaken in the Michigan cherry producing area in the 1962 season to relate scald index and red pigment evaluation with fresh and processed product grade. The portion of an inspector's sample graded as usable was further evaluated for scald and red pigment.

4. Italian prunes. Juice from a section cut on the side opposite the suture and equidistant from each end of 20 prunes had a soluble solid content approximately that of a composite juice sample from the same fruits. The soluble solids in the suture side were lower than those from other portions and there was considerable variation in solids of the 2 cheeks of the prune.

There was a general increase in the wavelength of peak light transmittance (Hortispect), flesh color (visual rating), and soluble solids (refractometer) with progressive pickings. Hortispect readings did not accurately indicate flesh color. When the flesh and skin were tested separately, the readings on the skin alone were about equivalent to that obtained on the intact fruit, while readings on the flesh alone were at wide variance. Hortispect readings on the flesh of light and dark colored prunes varied from 560 to 570, but varied from 570 to 610 on the skin. The latter readings corresponded closely to readings of the entire fruits. The high concentration of pigment in the skin of the prune appears to have the principal effect on the wavelength of peak light transmittance.

An increase in the wavelength of peak light transmittance occurred in storage at 32°, 36°, and 40° F. The change was most rapid with the higher temperature and was still changing at the end of a month in storage. There was a decrease in soluble solids during storage which was most noticeable in the less mature fruit and at the lower storage temperatures. Flesh firmness and total acid content of the prunes decreased in storage.

Severe flesh browning was encountered in some prunes when they were removed from cold storage and ripened at 70° F. Prunes stored at 36° developed the most browning and those at 32° the least. Dessert quality was poor when soluble solids at harvest were below 14 percent.

5. Peaches. Twelve breeding lines and varieties of peaches were processed for evaluation as purees. Considerable variation was found in color, texture, and soluble solids of the processed product. These findings were of benefit to the plant breeders for the selection of desirable genetic material.

B. Quality maintenance in handling and packaging

1. Apples. In three truck hauls from orchard to New York City (80 to 100 miles) apples in cell-packed cartons sustained the least bruising. Following in order of increasing damage were fruit in shrink-film overwrapped trays, polyethylene bags, tray layer packs, and jumble-filled packs.

The retail store condition of test lots of McIntosh apples in cell packs, poly bags, and shrink-film overwrapped trays was studied in early 1962. In New York supermarkets, fruit in overwrapped trays had less bruising and puncturing than cell-packed fruit sold in bulk, while poly-bagged fruit had the most bruising and puncturing. After a holding period the amount of fruit decay was greatest in poly bags and least in overwrapped trays. Experimental work has been completed and a manuscript prepared.

Mealy breakdown, one of the most serious disorders of California Yellow Newtown apples held in CA storage, had previously been found to occur in all lots stored at 40° F. in atmospheres of 0 to 10 percent carbon dioxide in combination with 3 percent oxygen. Fruit that was most mature at harvest appeared to be most susceptible to mealy breakdown.

Fruit was harvested on three different dates in the 1960-61 season (Sept. 28, Oct. 6, and Oct. 19) and was stored at 40° F. in atmospheres of 7 or 10 percent carbon dioxide in combination with 3-4 percent oxygen. When removed from storage in mid-June apples from all lots

were crisp and juicy. There was slight carbon dioxide injury in fruit held at 10 percent carbon dioxide. When the fruit was held for 1 week at 70° after removal from storage, 71 percent of the fruit from one orchard and 50 percent from another developed mealy breakdown. The disorder could not be correlated with harvest maturity or carbon dioxide level during storage.

To test the accuracy of the RSAVA formula, developed previously for film permeability and respiration equilibrium, 135 bushels of apples were stored at 30-32° F. in polyethylene, polypropylene, rubber hydrochloride, and polyvinyl chloride liners. Results of these tests indicate the respiration rate of the apples were within the ranges predicted in the tables developed from the formula. The permeable surfaces of apple liners were not significantly affected by tying the liner tops, and no correction factor is indicated for this closure. Apple temperatures within liners averaged 0.35° F. higher than in boxes without liners. The shipping container caused no significant difference in either the respiration or firmness of apples stored within liners. Firmness readings after 9½ months' storage in sealed liners indicated the performance of all liners used was satisfactory.

Pallet covers and bulk-box covers made of 2-mil polyethylene were beneficial in retarding moisture loss from Golden Delicious apples but were less effective than individual box liners. With the covers, moisture was still lost to the boxes or through the exposed bottom. In one test with fruit stored 5 months at 32° F. in field boxes, weight losses averaged 5.4% in boxes without liners, 3.4% in boxes stored under a pallet cover, and 1.6% in boxes with polyethylene liners. Visible fruit shriveling was extensive only in boxes without liners. Gas concentrations under the pallet covers and bulk-box covers ranged from 0.4 to 1.1% CO₂ and 19.4 to 20.7% O₂. Deterioration in the form of splitting followed by decay under the pallet covers was excessive only when fruit was too ripe for late storage. It was worse in top-layer apples in contact with condensation on the film.

Packets of hydrated lime inserted in cartons effectively absorbed excess CO₂ in 6 tests with Delicious, Golden Delicious, Stayman, and McIntosh apples. With no lime in the sealed liners, CO₂ averaged 5-8% during storage. With ½ pound of lime in a waxed paper or kraft paper bag, CO₂ was held near 1% for 2-3 months at 32°, and then climbed rapidly as the lime was neutralized. With 1 pound of lime, CO₂ was effectively absorbed within the liners and averaged less than 1% during 5 or 6 months' storage. Intermediate levels of 2-4% CO₂ were maintained during storage by inclosing cellophane or perforated polyethylene bags instead of paper bags to hold the lime. These restricted the contact of lime with the air more than kraft or waxed paper bags.

The use of lime in film-lined boxes of Red Delicious was beneficial, as the fruit was firmer after storage than that without lime and less scald developed.

Golden Delicious apples were dipped in solutions (1000 and 2000 ppm) of C₁₆ alcohol (cetyl) and C₂₀ alcohol and then stored 5 months at 32° F. At the higher concentration the material reduced weight loss during storage about 20% as compared with untreated apples. However, polyethylene liners provided much greater protection from weight loss and shriveling than did the alcohol coatings.

A test to compare the keeping quality of freshly harvested apples stored at 32° or 40° F. for 1 to 5 months in 4 pound perforated polyethylene bags (12 bags to master carton) or in bulk bushel boxes was initiated in the fall of 1961. Red Delicious and Jonathan apples from three orchards were used for the study. On removal from storage at monthly intervals apples were examined and placed on simulated retail display of either 7 days in a refrigerated case or 7 days at 70° F.

The data are not completely analyzed, but it appears that prepackaged apples stored as well if not better than bulk apples, mainly due to less weight loss, shriveling, and decay in the packaged apples. Apples in good condition probably can be safely prepackaged in film bags several months ahead of the time of sale if held in refrigerated storage. Both packaged and bulk apples shriveled more in the refrigerated case than at 70°.

2. Peaches. Hydrocooling and warming rates of peaches in 3 common shipping containers: baskets, wirebound crates, and corrugated cartons were studied. With hydrocooling water maintained at approximately 35° F., peaches in 3/4-bushel baskets, wirebound crates and corrugated cartons cooled from about 68° to 44° in 20 minutes. At the end of the hydrocooling period, peaches in the center of baskets and cartons were 3 to 7 degrees warmer than peaches in the top or bottom. The slowest rate of cooling in wirebound crates was in bottom layer fruit.

Peaches cooled to 54° F. by hydrocooling in containers before being placed at 70°, warmed to a constant temperature in about 18 hours. The rate of warming following hydrocooling was slowest in corrugated cartons and fastest in wirebound crates.

Cartons formed of corrugated board with flutes running at right angles to the flow of water in the hydrocooler retained only one-half the weight of water that was retained by cartons with flutes parallel to the flow of water.

An average of 24 percent of hydrocooled peaches in 3/4-bushel baskets were bruised as compared to 18 percent in boxes of similar capacity when stacked 5-high during simulated transportation to market. Bruising was rather evenly distributed from top to bottom in the stacks of baskets. Within the stack of corrugated boxes, little difference in incidence of bruising was noted in the top four boxes and each box contained less bruised fruit than a basket correspondingly placed in a stack. However, the number of bruised peaches was high in the bottom box of the carton stack, averaging 29 percent bruised fruits as compared to an average 15 percent in the top four boxes.

Bruises on peaches in baskets were more severe than those in boxes. Of all bruises, 35 percent of those found in baskets were greater than $\frac{1}{2}$ -inch in diameter as compared to 26 percent in boxes.

C. Quality maintenance in storage

1. Apples. In the 1960-61 season Starking Delicious apples picked at 140, 150, and 160-day intervals after bloom, and stored in controlled atmosphere storage, were slightly firmer at time of removal after 6 months and 8 months of storage than similar fruit held in regular storage at the same temperature. This difference disappeared after a few days at 70°.

The 140-day fruit from regular storage (check fruit) had as high quality as that from controlled atmosphere as judged by a taste panel, but the late-maturity fruit (160 days) was rated higher out of CA storage than the check fruit.

A differential in flesh firmness of approximately 2 pounds existed throughout the storage season between the early maturity and late maturity fruit stored in regular storage and in the CA room maintained at 2.5% oxygen and 0.5% carbon dioxide. Fruit from a room which was maintained at 2.5% oxygen and 5.0% carbon dioxide, softened more rapidly than the other lots when removed to 70° room. The 5% level of carbon dioxide was deleterious, to the fruit.

Fruit removed from controlled atmosphere storage on April 10 and placed in regular 31° storage exhibited the same firmness and total acid content in June as fruit held in CA storage until June. This indicated that the influence of CA storage on these properties was greatest during the fore part of the storage season.

As reported in previous years, the principal distinction found between apples from regular storage and CA storage was the higher acid content in the CA fruit. The acid contents of the 3 maturities at harvest were: 0.285, 0.241, and 0.233 percent. Upon termination of the tests in June, the acid percentages for the regular storage fruit were, 0.142, 0.119, and 0.096; for CA storage with 2.5% O₂ and 5% CO₂,

0.217, 0.169, and 0.173; for CA storage with 2.5% O₂ and 0.5% CO₂, 0.185, 0.160, and 0.167, respectively.

In the 1961-62 season Washington State Delicious apples were stored in controlled atmosphere rooms in which the oxygen level was lowered to 5% in 10 days, 20 days, and 40 days. No significant differences were found in quality of the fruits from any of these lots as determined by flesh firmness, soluble solids, pH, total acid, or flavor after a full seasons storage. The data indicate that the State Law requiring that oxygen be lowered to 5% within 20 days to qualify apples for a CA label, may be more stringent than necessary.

Fruit from a room with 2.5% oxygen was only slightly firmer than that from the room with 5% oxygen, but the difference was statistically significant. No consistent differences were found for solids, pH, acidity, or flavor, although results slightly favored the room with 2.5% oxygen.

Mealy breakdown of California Yellow Newtown apples after removal from controlled atmosphere storage has been a serious problem in some years. Research was conducted to relate this disorder to (1) the vigor of the tree, (2) the field temperature of the fruit (as affected by northern or southern exposure on the tree), (3) the temperature in storage, and (4) the composition of the atmosphere in storage.

Apples examined after 9½ months' storage had no mealy breakdown or internal browning. However, fruit stored at 38° F. was firmer and greener than that stored at 40°. Apples stored in 6 percent CO₂ and 3 percent O₂ (6:3) were slightly firmer and greener than those stored in a 3:3 atmosphere. Fruit stored in either of these atmospheres was much superior to that stored in a 6:8 atmosphere. Yellow Newtowns held in the latter atmosphere had about 10 percent scald; those in the 6:3 atmosphere had no scald; and those in the 3:3 chamber had only a slight amount in one lot.

After 2 weeks at room temperature, mealy breakdown affected from 6 to 22 percent of the fruit harvested from young vigorous trees and subsequently stored in modified atmospheres. Fruit harvested from old, less vigorous trees was practically free from mealy breakdown. Fruit from the south side of the young trees had about 1.5 times as much breakdown as that from the north side. Slightly less breakdown occurred at 38° F. than at 40°.

Respiration rates taken at 53° F. after the storage period showed that of the apples previously held in the 3 different atmospheres, those in the 6:8 atmosphere respired fastest and those in the 6:3 atmosphere respired slowest.

2. Bartlett Pears. Polyethylene liners are commonly used in L/A lugs for large-size Bartlett pears marketed in the West. Previous work indicated that storage disorders were affected by the degree of ventilation in the liners, and by the maturity of the fruit at harvest. In current studies, fruit was harvested on three dates (Aug. 10, Aug. 17, and Sept. 1) and stored without liners, in sealed liners, or in liners perforated with five pin holes. Fruit from each harvest was stored at 31° F. until December 5 or January 30.

At the first withdrawal from storage (December 5) all fruit from the first 2 pickings ripened with excellent quality and no core browning. Fruit of the third picking developed much more core browning in either sealed or ventilated liners than without liners.

Fruit withdrawn for ripening on January 30 showed a similar trend, but only the first picking ripened without any core browning. The disorder was most severe in the last picking and worse in liners than in containers without film liners.

3. Bosc Pears. Bosc pears harvested on September 13 were packed in sealed or multi-perforated polyethylene liners or without liners and stored for 3 or 5 months.

Carbon dioxide and oxygen levels after 3 months' storage were 3.4:16.7 in the sealed liners and 1.3:20.3 in the perforated ones. The atmospheres were about the same after 5 months' storage.

The fruit ripened without internal breakdown after both storage periods. Quality, however, was relatively poor in all lots, the fruit being mealy and lacking juice. The poor quality was not a result of storage conditions, however, since fruit ripened immediately after harvest was also poor.

4. Plums. During the 1961 season Santa Rosa plums from two locations in the San Joaquin Valley were stored at 30°, 32°, 36°, or 41° F. for 2, 4, or 6 weeks. The plums were divided into two groups based on appearance. Plums of one group had large, prominent lenticels, which gave them an almost russeted appearance, and those in the other group had small, inconspicuous lenticels, were smooth and uniformly colored. The "russeted" fruit was 2-3 percent higher in soluble solids and superior to the smooth plums in flavor. Keeping quality was not affected by type.

A breakdown associated with overripeness which appeared after 6 weeks' storage was most severe at the two highest temperatures. In a parallel experiment, in which plums were divided into three maturity classes based on color, the only breakdown was in the more mature fruit held at 36° and 41° F.

Three new plum varieties were picked at weekly intervals and the soluble solids content and firmness determined throughout a storage and ripening period. The Nubiana and Laroda varieties, stored for 6 weeks at 32° F., ripened after removal from storage, to good dessert quality if the initial soluble solids content was between 16 and 18 percent. Soluble solids content remained constant during storage. Sound Nubiana plums picked as late as August 16, 3 weeks after the commercial picking date, were still firm enough on October 1 to require 5 to 7 days at 65° F. to ripen. Queen Anne plums had a lower soluble solids content and did not store as well as the other two varieties.

During the 1962 season commercially harvested Nubiana plums were held at 60° F. to determine if they were capable of normal ripening. Two lots averaging less than 15 percent soluble solids did not ripen with satisfactory quality. One lot averaging slightly above 15 percent soluble solids ripened to fair quality.

When Nubiana plums were stored for 7 weeks at 34° F. in sealed polyethylene lug liners, the resulting modified atmospheres (CO₂ 7%, O₂ 11%) reduced decay, prevented ripening in storage, and delayed ripening during subsequent holding at 70°. This modified atmosphere did not produce off flavors, odors, or other harmful effects.

5. Grapes. Emperor grapes were hydrocooled in the packed lug boxes and fumigated with 1.0 or 0.5 percent SO₂ for 20 minutes prior to storage. The half-cooling time was less than 2 minutes. Wet grapes and containers absorbed about twice as much SO₂ as dry grapes and containers. After 3 months' storage, the hydrocooled fruit had less weight loss and slightly less decay than fruit that was cooled in air. Both the stems and berries of the hydrocooled fruit had a better appearance than fruit in check lots, as evidenced by brighter color and less dessication.

6. Dried fruits. In cooperation with the Dried Fruit Association of California a survey was conducted in 1960-61 to compare the quality of dried fruit in retail stores with the initial quality at time of packing. Temperatures and relative humidities were taken in retail stores and the length of time dried fruits remained in marketing channels was determined. A total of 678 packages of dried fruit was carefully examined. Seven percent of the apricot samples, 11 percent of the prune samples, 13 percent of the raisin samples, and 17 percent of the fig samples collected in retail stores were of poor quality because of excessive darkening, insect infestation or other defects. Aging was the primary cause of deterioration, but inadequate packaging and high store temperatures also contributed to excessive deterioration.

7. Strawberry plants. A storage test using $\frac{1}{2}$ million Catskill strawberry plants was conducted in a commercial storage at Salisbury, Maryland in 1962. The objective was to evaluate the cooling rate of 3 types of packages and 3 stacking patterns. The storage was at $30 + 1^{\circ}$ F. with forced air circulation for a period of one month. Cooling was substantially slower in solid stacks of containers than in spaced double or single stacks, as would be expected. Plants packed in fiberboard cartons cooled slower than those in standard wirebound crates.

D. Quality maintenance during transportation

1. Pears. In cooperation with the California Tree Fruit Agreement shipping tests were conducted during the 1961 and 1962 seasons to determine suitable transit protective services for the initiation of ripening in Bartlett pears during transit to eastern markets.

Modified icing of standard refrigeration cars provided the moderate temperatures needed for initiation of ripening, but the amount of ice required depended on the flesh firmness and temperature of the fruit. Fruit of 19 pounds pressure test or higher, and 75° F. or lower in temperature, required only an ice replenish at the first icing station and one reicing at Chicago. If initial temperatures were warmer (75° to 85°) two reicings were needed (Council Bluffs, Iowa and Marion, Ohio) and if above 85° the two reicings were needed earlier during the transit period (Ogden, Utah and Chicago, Illinois). All of these are half-stage services. If the fruit was below 19 pounds at harvest, either full-bunker icing or more reicings at half-stage was needed. If the fruit was mature enough to require pre-cooling, then one reicing was enough (full bunker). This would cost \$80.49 less per car than standard refrigeration.

In test shipments of early-season California Bartlett pears to eastern markets in thermostatically controlled rail cars average transit temperatures near 60° F. were suitable for fruit with initial firmness near 20 lbs. and with loading temperatures below 75° . Average temperatures near 55° were desirable for fruit with initial firmness near 18 to 19 lbs. and with moderate loading temperatures.

Modified, half-stage icing of standard cars was used as a comparison with Ice Tempco and mechanical cars, which have thermostatic control. Shipping pears in a pre-iced car, which was replenished at the first reicing station, and was re-iced twice in transit (Council Bluffs, Iowa and Marion, Ohio) provided average temperatures near 55° F. The pears required about 3 to 4 days' time to ripen after arrival in New York.

Ice Tempco cars equipped with a ceiling duct were found to provide relatively uniform temperatures through the load. Temperatures in cars without a ceiling duct were not uniform. Some mechanically refrigerated cars also had fairly large temperature differences between one end of the load and the other.

2. Strawberries. Preliminary tests to compare refrigerated express and freight service from California to Chicago for strawberries indicated that express shipments were slightly superior but that freight service was feasible. Further shipments are required to properly evaluate the two methods of shipping.

3. Grapes. When precooled grapes were fumigated in an Ice Tempco refrigerator car equipped with a ceiling duct, all the fans had to be turned on during the fumigation to obtain reasonably uniform SO_2 concentrations in the load. Following this procedure, maximum concentrations in the space above the load, and in boxes in the "A" and "B" ends of the car were 0.6, 0.3, and 0.4 percent, respectively. When only the by-pass fans were operating, comparable SO_2 concentrations were 1.2, 0.03, and 0.8 percent. The doors or hatches had to be opened to remove the SO_2 from the car in a reasonable time.

4. Blueberries. Forced air cooling of packaged blueberries showed that in commercial pallet load quantities (78 to 156 crates of 12 pints each) half cooling times of about 1 hour or less were possible with air movement of about 4 c.f.m. per pint or about 2 hours with air movement of about 1 c.f.m. per pint. Forced air cooling was four or more times faster than that currently obtained by conventional methods of room cooling.

Increasing the amount of nitrogen fertilizer applied during crop development decreased fruit acidity, soluble solids, dry weight and keeping quality and increased total yield slightly. Fruit with less than 0.6% acid or a pH higher than 3.25 at harvest did not keep as well as fruit with more than 0.6% acid or pH values below 3.25.

5. Simulated transit in nitrogen atmospheres. Peaches developed a fermented flavor when held in 100% nitrogen at 60° F. for 4 days or longer, but remained normal in flavor when held in 99% nitrogen at the same temperature with 1% oxygen for periods up to 10 days. Little softening occurred in fruits held in 100 percent nitrogen as compared to that occurring in fruits in 99 percent nitrogen or in normal air. Development of Rhizopus and brown rot of peaches was prevented in 100 percent nitrogen and retarded in 99 percent nitrogen.

The growth of mold was prevented on strawberries held at 33° F. in 100% nitrogen, but not in 99% nitrogen with 1% oxygen or in normal air. Berries held in 100% nitrogen softened more rapidly than in the other atmospheres. Strawberries held in 99 or 100% nitrogen kept as well after removal to normal air as fruit held continuously in normal air. Flavor of strawberries was not affected by holding the berries in 100% nitrogen at 33° for periods up to 10 days.

Growth of *Penicillium digitatum*, *Botrytis cinerea*, and *Sclerotinia sclerotiorum* in vitro was inhibited in 100 percent nitrogen but not in 99 percent. Growth of *Phomopsis* spp. was retarded in 100 percent nitrogen.

E. Post-harvest physiology

1. Apple scald. During the year the Food and Drug Administration granted clearance for use of diphenylamine (DPA) to control apple scald with a residue tolerance of 10 p.p.m. on treated fruit. This action culminated 6 years of evaluating DPA on various varieties and obtaining toxicological data to determine its safety. Apples may now receive a postharvest dip or spray in 1000-2000 p.p.m. wettable powder suspensions of DPA, be wrapped in DPA impregnated tissue paper, or receive a pre-harvest spray of DPA within a day or two of harvest. The pre-harvest sprays are less effective than postharvest treatments. Another scald inhibitor, ethoxyquin, was cleared for commercial use in 1960.

Fourteen tests were conducted to compare effectiveness of various application procedures for DPA and ethoxyquin on eastern apples. On early picked Delicious and Rome apples, considerable scald developed even on the treated lots, indicating that care in selecting a picking date will continue to be important. The use of wettable powder formulations of DPA may require higher treating concentration than alcohol suspensions of DPA, to obtain the same scald control. Suspensions of DPA and ethoxyquin heated to 120° F. and used as a 5-10 second dip usually gave better coverage and better scald control than 60° treatments. A 2-week delay after harvest before treating markedly reduced the effectiveness of both scald inhibitors. Spraying fruit in field boxes with scald inhibitors gave nearly as good scald control as dipping. Golden Delicious were not injured by dipping in 2700 p.p.m. ethoxyquin or 2000 p.p.m. DPA in wettable powder form.

Dipping Red Stayman apples in warm water (30 sec. at 140° F. or 60 sec. at 130°) soon after harvest controlled scald as well as treatment with DPA, but Red Delicious, Grimes Golden, Winesap, and York were severely injured by the heat treatments.

DPA treated molded-pulp trays and DPA treated polyurethane layer pads, made by soaking in 4000 p.p.m. DPA suspensions before use, provided good scald protection for Stayman apples. However, the treated polyurethane pads caused severe skin injury.

Stayman apples from 3 different pickings were separated by light transmittance techniques into 3 groups based on internal chlorophyll content. There was no relationship between internal chlorophyll and subsequent scald development at any one picking. Grading apples by light transmittance does not appear to be a promising method of pre-determining scald susceptibility. DPA dip treatments provided the most complete scald control on late pickings.

2. Apple respiration in modified atmospheres. Instrumentation problems have delayed progress of this PL 480 project. However, sufficient data have been obtained to show that the presence of above normal concentrations of CO₂ in the storage air depresses the output of carbon dioxide from apples less than it does the uptake of oxygen. Respiration determinations at five temperatures from 32° to 45° F. in normal air showed that both carbon dioxide output and oxygen uptake more than doubled with a 13° F. rise in holding temperature.

3. Anjou pear scald. Anjou pears harvested in the Wenatchee Valley at 140, 145, 150, and 160 days after full bloom were dipped in a suspension containing ethoxyquin and then wrapped in plain paper wraps. Untreated samples were wrapped in plain paper and in oiled basic copper sulfate paper. The fruit was packed in perforated polyethylene liners and stored at 30° F. until mid-April. Scald and decay counts were made after a ripening period of 7 days at 70°. Results showed substantial scald and decay control with both treatments, as compared with the control, but considerably better decay control was obtained with the oiled basic copper sulfate wrap than with ethoxyquin.

4. Brown core of pears. Contract research at Oregon State University confirmed previous findings that early-picked Anjou pears showed only a slight amount of brown-core development. However, in fruit picked at mid-season during 1961 considerably more brown-core occurred than in previous seasons. Slow cooling did not increase severity of brown-core, but a delay of 4 days at 70° before storage caused more injury. Low oxygen tends to increase severity of injury.

Anjou pears from low vigor trees developed more brown-core than those picked the same day from high vigor trees. Fruit from the high vigor trees were firmer at harvest indicating that they were less mature.

Fruit with brown-core has consistently shown high succinic acid concentrations in the injured tissue.

Promising results in maintaining desired CO₂ concentrations in sealed film liners were obtained by the use of lime in various types of paper bag. A pad made of waxed Kraft appears promising.

5. Blueberries. The relation of fruit-leaf ratios and temperature during the harvest season to several fruit quality factors were measured with blueberries from plants grown on nutrient solutions in the greenhouse. High temperature during this period decreased fruit acidity. Fruit-leaf area ratios were related to soluble solids, rate of ripening, and to acidity to some extent. Keeping quality decreased noticeably toward the end of the harvest period for fruit from each bush indicating this same response noted in field tests is associated in some way with the physiology of the plant.

6. Leucoanthocyanins and astringency in peaches. In earlier studies a number of polyphenolic compounds were identified in Elberta peaches of various maturities. One of these groups of compounds, leucoanthocyanins, has been found to have a small water insoluble fraction associated with the vascular elements or transporting tissues within the fruit. Leucoanthocyanins are probably responsible for a major portion of the astringency in peaches but no appreciable change from the soluble to insoluble form was found during ripening. (Pioneering Laboratory Project)

7. Mitochondria and other particles in apple cells. Further studies with apple mitochondria have shown that cytochrome oxidase and DPNH cytochrome c reductase activities can be demonstrated in the particles if careful pH adjustments and other protective measures are taken. Several of the cytochromes have been identified in low temperature spectra of these particles. These activities are in addition to the earlier demonstrated Krebs cycle acid oxidations and provide a means for a basic study of respiratory mechanisms. Work is continuing with various particles isolated from apples and other tissues and their production of ethylene and related gases. A natural emanation from fruit has been found recently that inhibits ripening. (Pioneering Laboratory Project)

8. Mode of action of diphenylamine (DPA). The effectiveness of DPA for controlling apple scald has been shown by experiments in many laboratories but its mode of action has been almost entirely unknown. DPA inhibits the cytochrome electron chain of isolated particles in a region differing from the effect of other classical inhibitors of respiration such as azide and antimycin A. Two compounds besides DPA have been found to have a similar effect on the electron transport chain. These are N-para-tolyl-1-naphthylamine and N-phenyl-beta-naphthylamine. One of these compounds has already been shown by another laboratory to be effective in controlling apple scald. (Pioneering Laboratory Project)

F. Post-harvest disease control

1. Apples. Work was continued on the assay of pectin-splitting enzymes of Penicillium expansum, Neofabraea perennans and Botrytis cinerea. Culture filtrates of the three organisms grown on a straight synthetic medium and on a synthetic medium containing 50% apple juice reduced the viscosity of pectin solutions. The juice from apples rotted by Penicillium also reduced the viscosity of pectin solutions, while that from apples rotted by Botrytis did not. Optimum pH for enzyme activity of culture filtrates of Penicillium was pH 4.0, while the optimum for the juice from rotted apples was pH 6.0. Optima for Botrytis and Neofabraea were pH 3.0.

A heat-labile, non-dialyzable factor which increased the viscosity of pectin solutions was detected in the juice from apples rotted by Botrytis cinerea. The exact nature of this factor is unknown, but its presence may explain the difference in the texture of apples rotted by this organism, and that of apples rotted by Penicillium expansum.

Three commercial lots of captan were used to determine the nature of the chemical injury previously reported on Winesap apples. Injury, resembling storage scald, occurred only on fruit treated with the captan from the same source as that which caused the injury the previous year. The amount and intensity of injury increased in fruit that was treated later in the season. Apparently an impurity in this particular lot of fungicide is responsible for the injury.

Mixtures of captan, SOPP (sodium orthophenylphenate), and DHA-S (sodium salt of dehydroacetic acid) with either diphenylamine (DPA) or ethoxyquin reduced the scald inhibiting properties of the latter two materials. Thirty-one percent of the fruit treated with the mixture of DPA and ethoxyquin exhibited chemical injury. Fruit finish was poor on fruit treated with SOPP or DHA-S combined with either of the scald inhibitors. In view of the foregoing problems with mixtures of fungicides and scald inhibitors, it appears that the application of these materials will have to be a two-step operation in which the fungicide treatment will have to be followed by a clear water rinse before the scald inhibitor is applied.

2. Peaches. The concentration of Dowicide A was reduced from 0.09% to 0.06% during $1\frac{1}{2}$ hours of hydrocooling in a pilot scale ice-refrigerated, flood-type hydrocooler. The pH of the solution also changed from pH 11.6 to 10.7. When solutions containing 0.1% Dowicide A and adjusted to pH 11.5 were frozen and the ice thus obtained was used to hydrocool peaches for $1\frac{1}{2}$ hours the concentration of Dowicide A remained almost constant and pH was reduced only to 11.2.

Reduction of *Monilinia* (brown rot) or *Rhizopus* decay by this chemical was erratic. Earlier experiments showed that concentrations of 0.05% and lower of Dowicide A were relatively ineffective in reducing post-harvest peach decays. Maintaining the concentration of this chemical in hydrocooling solutions at approximately 0.1% through the use of ice containing the chemical gave effective decay control when the fruit was inoculated shortly before treatment. Erratic decay reduction of peaches with natural infection was considered to be due to the failure of the chemical to reach incipient infections.

The chemical 2,6, dichloro-4-nitroaniline was extremely effective in reducing both *Monilinia* and *Rhizopus* decay either when the fruit was freshly inoculated or when inoculated 24 hours before treatment. It had a static effect on *Monilinia* infections limiting the infections to small spots. It almost completely prevented *Rhizopus* infection.

During the 1961 season hot water treatments were shown to adversely affect organisms on the surface of the fruit and even after penetration below the skin. *Rhizopus* and *Monilinia* decays of peaches were almost completely absent after 2 days holding at 70° F. when freshly inoculated fruit was submerged for 7 minutes in 120° water, 3 minutes in 130° water or 2 minutes in 140° water prior to placing at 70°. A high percentage of the fruit was still sound after 8 days at 70° whereas the check fruit, (dipped in room temperature water) was almost completely decayed after 4 days at 70°. When hot water treatments were applied 24 hours after inoculation they were equally as effective in reducing decays as with freshly inoculated peaches. Temperatures just under the skin after hot water treatment ranged between 105 and 115°. Pit temperatures usually were 5 to 10° higher than the original temperature of the fruit. Treated fruit with 95° pit temperatures was cooled in a flood-type hydrocooler to below 50° in 20 to 25 minutes. Hot air treatments in which the temperature just under the skin reached approximately 105° were not as effective in reducing decay as hot water treatments.

Continued research with hot water dips in 1962 showed them to be effective in reducing both *Monilinia* and *Rhizopus* decay of peaches during subsequent holding at 70° F. Dips for 1½ minutes in 130°, or 3½ minutes in 120° water reduced *Monilinia* decay as effectively as 3 and 7 minute dips respectively, but were slightly less effective in reducing *Rhizopus* decay. Limited data show that when peaches are transferred to 50° F. immediately after heating in 120° or 130° water or hydrocooled and held at 50° after heat treatment, *Monilinia* decay is reduced as effectively as when peaches are placed at 70° immediately after heating. *Rhizopus* decay however, was higher when peaches were hydrocooled. Much of the *Rhizopus* decay is believed to be due to contamination from the container. Injury sometimes

occurred when peaches were hydrocooled after heating. Injury was not evident when peaches were hydrocooled to about 65° rather than 50°.

Hot air (130° F.) reduced both *Monilinia* and *Rhizopus* decay of peaches, about as effectively as hot water, but required longer exposure. Air with 80, 90, or 95 percent relative humidity was somewhat more effective in reducing decay than air at 35, 50, or 60 percent relative humidity. At the higher relative humidities in 130° air peaches heated more rapidly and to higher temperatures than in 130° air at the lower relative humidities.

When peaches partially decayed by *Monilinia* or *Rhizopus* were heated in hot water the organisms near or on the surface were killed or severely weakened. Spores from the surface of treated peaches did not germinate when streaked on agar plates, and no growth occurred from isolations made about $\frac{1}{4}$ inch under the peach skin. Growth did occur, however, from about 80 percent of the isolations made from decayed flesh near the peach pit.

Rhizopus spores on swab sticks were killed more rapidly at 120° or 140° F. when the relative humidity during exposure was 80 or 90 percent than when the relative humidity was 50 or 70 percent.

Preliminary trials with Southland peaches inoculated with brown rot (*Monilinia fructicola*) indicate disease control by gamma irradiation is dependent upon dose rate. Within the range of 157,000-210,000 rads an average fast rate of 22,000 rads/min. was more effective than an average rate of 2,200 rads/min. The fast rate within the range of 157,000-182,000 rads was as effective as the slow rate at 210,000-250,000 rads. Injury to the fruits was not affected by dose rate.

A fruit rot of Indiana peaches not previously observed on peaches in the Chicago market was investigated. The decay is characterized by light-brown to brown-circular to irregular areas on the surface of the fruit. The fruit retains its shape and the decay, which may extend to the pit, is fairly firm in texture. Isolates made from the advancing area of the decay yielded an organism which appears to have the cultural and morphological characteristics of Phytophthora sp.

To complete the study of *Rhizopus* decay in peaches for processing the rate of growth of *Rhizopus stolonifer* was compared at 10 degree temperature increments between 40° and 90° F. Growth rates on culture media were highest at 70° F. and lowest at 40° and 90°. Growth of the organism on peaches was highest at 86° and higher at 90° than at 70°.

3. Grapes. The distribution of sulfur dioxide during the fumigation of grapes in railway refrigerator cars and cold storage rooms was studied in an effort to improve decay control and reduce injury to the fruit.

Although uniform gas distribution had been obtained previously in the two-bunker Carotemp experimental car, poor distribution of gas was obtained in the new single-bunker "Ice Tempco" cars. Using the by-pass fan during the fumigation, the maximum concentration of gas in a lug box of grapes in the middle layer, quarterlength position, in the end of the car opposite the bunker was 0.2 percent, compared to 0.8 percent in a comparable position in the end next to the bunker. The maximum concentration in the space above the load was 1.2 percent. In a car loaded with grapes in a different container, the TKV lug, the maximum concentrations of SO_2 in the two respective positions were 0.07 and 0.37 percent. Use of all the car fans after the fumigation did not exhaust the gas satisfactorily.

A common commercial practice is to fumigate grapes in conventional refrigerator cars without fans to distribute the gas. The gas is usually left in the cars until they are "pulled" from the shed. Gas concentrations under these conditions were found to be very uneven and 0.1 percent SO_2 was detected 3 hours after the start of the fumigation. The grapes in the top layer of this load were injured.

A cold storage room fumigated with a calculated 0.25 percent concentration of SO_2 had the calculated concentration of gas in the space above the stacked fruit, but only 0.17 percent gas in the channels between boxes on a pallet, and no measureable amount in the center of the box. The type of grape containers, the tightness of the pack, and the type of lid affected the concentration of gas within the box.

Grapes inoculated with Botrytis spores were treated with sulfur dioxide after various incubation times. Within 6 hours after inoculation and incubation at 68° F. and saturated RH, exposure to 100 p.p.m. sulfur dioxide at 95 percent RH for 12 minutes effectively controlled decay. Fumigation with the same dose at 58 percent RH did not reduce decay. After a 20-hour incubation period exposure of the grapes to 2,000 p.p.m. for 30 minutes reduced the decay from 96 percent to 53 percent.

Alternaria spores were found to be more resistant to sulfur dioxide than Botrytis spores, but like Botrytis, the sulfur dioxide was much more toxic in the presence of water. The germination of wet Alternaria spores was completely inhibited by exposure to 400 p.p.m. sulfur dioxide for 2 minutes or 100 p.p.m. for 20 minutes. Fumigation with 1,000 p.p.m. at 90 percent RH for 12 minutes and with

4,000 p.p.m. at 80 percent RH for 10 minutes was required for complete inhibition of germination.

4. Pears. A gamma dose range of 125,000-150,000 rads was effective for gray mold control on both Bartlett and Anjou pears. In the range of 100,000-150,000 rads, a fast dose rate of 25,000 rads/min. was more effective in disease control than 2,500 rads/min. in Bartletts, and less so in Anjous. Doses of 200,000 rads either delayed or prevented normal ripening in both varieties. 25,000 rads/min. was more injurious than 2,500 rads/min. with Bartletts but not with Anjous. Irradiated, slightly unripe fruit of each variety ripened normally at 76° F. regardless of dose. Irradiated hard-green fruit did not ripen normally after exposure to a dose of 200,000 rads.

5. Cherries for Brining. Cherries were inoculated with Cytospora leucostoma, Penicillium expansum, Aspergillus niger, Rhizopus stolonifer, Botrytis cinerea, and Monilinia fructicola. After approximately 1/2 of each fruit had rotted, sound and rotted cherries were brined together. Sound cherries brined with fruits rotted by C. leucostoma, P. expansum, and A. niger softened in the brine. Juice squeezed from cherries rotted by the 6 organisms was stored in a freezer. Pectin splitting enzymes were detected in all of the preparations except from fruit rotted by M. fructicola. The pectin splitting enzymes in the juice of fruit rotted by B. cinerea and R. stolonifer were largely inactivated by holding at room temperature (75°) for 72-96 hours. The enzyme from R. stolonifer was inactivated further when incubated in the presence of bisulfate brine at room temperature. There was little or no loss in the activity of enzymes in the juice of fruits rotted by C. leucostoma, A. niger, or P. expansum under the same conditions.

6. Strawberries. Studies on the use of sulfur dioxide fumigation for control of decay in strawberries were continued. Exposure to concentrations of 200 to 400 p.p.m. for 20 to 30 minutes reduced decay to about one-half the levels observed in comparable untreated lots held for the same time. Very little injury was observed at these concentrations. Sulfur dioxide delayed the development of decay for about 24 hours.

In a preliminary experiment, holding strawberries at 32° F. for 5 days reduced the amount of Rhizopus decay that developed during a subsequent 3-day period at 68° F. but Botrytis decay was increased.

Additional studies on the effect of 32° F. storage on subsequent development of Rhizopus decay did not confirm the preliminary results. No consistent reduction in decay was obtained during 2 days at 65° following the low temperature holding.

Sparkle strawberries were treated with post-harvest dips of Harven (dehydroacetic acid) and Botran (2, 6-dichloro, 4-nitroaniline) to test the effectiveness of these substances in reducing post-harvest spoilage. The Botran treated berries had the least spoilage followed in decreasing order by Harven, dry control, and wet control.

Botran or Thylate field sprays on 1-year-old Potahantas or Sparkle strawberry beds did not reduce postharvest fruit decay due to Botrytis or Rhizopus regardless of the time and number of spray applications. However, when Botran was used as a postharvest dip at 200 p.p.m. decay was reduced.

Exposure of strawberries in boxes to hot air (110° F.) for 1 hour reduced postharvest decay as much or more than the Botran dip. Decay reduction was better when the relative humidity of the air was 90 percent or higher than when it was 60 percent. Slight scalding of the fruit sometimes occurred. A 7 minute dip in hot water (110°) also reduced decay but caused a medium surface scald on some fruit. The heat injury was more severe when Botran was added to the hot water.

The senescence inhibitor, N⁶ benzyladenine, was tested as a post-harvest dip of 20 and 50 p.p.m. on Pocahantas strawberries. After 4 days at 50° F. plus 2 days at 70°, the chemically treated berries were no better in appearance or condition than the non-treated.

Leather rot (Phytophthora cactorum) and Rhizoctonia brown rot (Rhizoctonia sp.) are two diseases occasionally observed in the Chicago market on strawberries from the southeastern states. California strawberries examined this summer showed small percentages (.5 to 2.0) of each of these diseases. There are no previous records of the occurrence of these two disorders on California strawberries arriving on the Chicago market.

7. Cranberries. Film liners and CA storage -- CA storage tests were continued for a second year. In this year's study the relative humidity of the CA chambers was regulated as well as the CO₂ and O₂ levels. None of the controlled atmospheres offered commercial possibilities for increasing storage life beyond that attainable in normal atmosphere. Fruit stored in sealed polyethylene liners decayed more rapidly than that in any other treatment. None of the CA treatments damaged the flavor of cooked fruit.

The effectiveness of a series of hot water and fungicide dip treatments on reducing spoilage of cranberries were evaluated. Water temperatures of 125°, 120° and 70° F. were tested. The fungicides tested were the sodium salt of dehydroacetic acid and Botran

(dichloronitroaniline). A delayed treatment and the effect of fluctuating storage temperatures were also studied. Examinations after 3 and 5 months in storage at 38° showed that none of the treatments reduced spoilage below that on control lots.

A supplemental test was included in which half of a lot of healthy berries were inoculated with cranberry pathogens and half were not. Samples of these were treated by dipping in water at 50° (controls) or 125° F. After a holding period at 38° isolations were made from spoiled berries from each lot. Growth of cranberry pathogens occurred in 75% of the isolates made from the controls and in only 6% of those from the 125° dips. The hot water treatment apparently reduced spoilage due to microorganisms but not that due to physiological breakdown.

8. Pesticide Residues. Under a PL 480 project in Finland a detailed study is being made of captan and malathion residues on fruits and vegetables as a result of different post-harvest applications of these materials. Results to date show that captan has a rather prolonged residual effect, but that such residues on fresh products can be easily removed by surface washing and disappear practically completely in preservation processes.

Malathion, on the other hand, has a very limited residual life even on fresh produce. Its low toxicity and high disappearance during processing are advantageous from a safety standpoint. Both captan and malathion appear to be quite safe for post-harvest use; one for the reduction of post-harvest decay and the other for the control of insect contamination.

9. X-ray Detection of Fruit Diseases. Under a PL 480 project in Italy an investigation is being made of the usefulness of X-rays for detecting disease in fruit and the pathological changes taking place in the intact fruit. No experimental data are available yet.

G. Prevention of insect infestation

1. Basic Biology and Ecology. A great deal has been learned about the ecological and environmental factors influencing the behavior, flight, and distribution of several species of drosophila in the San Joaquin Valley of California. It has been learned this insect is able to fly as much as 6.4 miles in 24 hours rather than a few hundred yards as formerly believed. This emphasizes the infestation hazard involved for maturing grapes and figs, as well as for wineries and dried-fruit processing plants, by the close proximity of cull fruit dumps and decaying produce or harvest waste in the fields. Other information obtained will aid in developing practical preventive and control measures.

2. Insecticide Evaluation. A proportionate share of the program at Savannah, Georgia, has been charged to this area although much of the work is directly applicable. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13.

3. Insecticidal Control. Several insecticides were applied to growing grapes to evaluate their effectiveness in controlling drosophila infestations. Infestations result in, or accompany, a microbiological breakdown called bunch rot. These tests showed that vineyards dusted with dimethoate or malathion at the rate of 35 pounds per acre produced more grapes, if treated before bunch rot appeared. Two treatments of naled dust applied at the rate of 50 pounds per acre gave better control of drosophila than three treatments of 35 pounds per acre for a similar 3-week period.

Several insecticides were evaluated against drosophila and the dried-fruit beetle in cull-fruit-dump breeding areas. Granular formulations were not effective when sprinkled on piles over 24 inches deep. However, on piles of less depth, 5-percent heptachlor, 4- and 10-percent malathion, or 2-percent endrin gave good control for 2 weeks. The application rate was 8 pounds of granules per 100 cubic feet. Six pounds of 5-percent granular malathion mixed throughout a 100-cubic-foot, or one-ton mass gave good drosophila control. Three chemicals in wettable-powder form gave good control when mixed with water and sprinkled on the piles at the rate of 8 gallons per 100 cubic feet. These were Guthion (1 lb. of 15-percent), Dylox (1 lb. of 50-percent), and Bayer 29493 (0.5 oz. of 47-percent).

Drosophila are attracted to wineries in large numbers during the summer months. Methods of prevention and control have been evaluated. Installation of 24x24 mesh hardware-cloth screening and painting it and all window frames with a malathion emulsion is effective in excluding and killing many of the flies. Evaluation of aerosol applications of synergized pyrethrum or DDVP disclosed that a single treatment with the latter was effective for 3 to 5 days, while it was necessary to use pyrethrum as often as twice daily.

While grapes are drying on paper trays in the field and when raisins are placed in storage they are subject to attack by several species of insects. Results of exploratory tests indicated that malathion-treated drying trays offer protection against the live infestation that originate during the drying period and that would otherwise be carried into storage. It was also found that the malathion residues imparted to the raisins from the treated trays were sufficient to protect the raisins against insect infestation during at least 5 months of storage while awaiting processing and packaging.

4. Insecticide Residue Analysis. As with insecticide evaluation, the cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13.

5. Insect-Resistant Packaging. As with insecticide evaluation and residue analysis, the cross-commodity packaging work at Savannah, Georgia, is reported in Area 13.

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TRANSPORTATION AND MARKETING FACILITIES
Transportation and Facilities Research Div., AMS

Problem. Returns to producers and prices paid by consumers for deciduous fruit and tree nuts are adversely affected by the use of inefficient marketing facilities, equipment, and methods. Better work methods, techniques, devices, operating procedures, equipment, and facility designs are needed for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing.

Many of our conventional consumer packages and shipping containers are relatively expensive, require a substantial amount of labor to assemble, fill, and close; are comparatively heavy, hence costly to transport and difficult to handle; are unsuitable for storage; do not adequately protect their contents from damage; fail to make an attractive retail display to stimulate impulse buying; and lose potential sales because of poor visibility provided for contents.

Much of the transportation equipment now in use fails to give adequate protection to the more perishable commodities. Methods of loading often leave the container and product subject to mechanical damage in transit, result in poor utilization of available transportation equipment and hamper effective refrigeration. The substantial savings in labor costs incident to mechanized handling accomplished in other areas are not being realized in agricultural transportation. In the field of air transport, provisions for efficient and economical handling to and from airports and protection against heat and cold are inadequate. In the area of water transportation the arrival condition of fruits and vegetables due to inadequate refrigeration, container, and stowing problems has seriously affected the market for United States products abroad.

USDA PROGRAM

Research on marketing facilities, equipment and methods is a continuing long-range program involving engineering research covering the development of improved work methods, techniques, devices, operation procedures, equipment, and facility designs for precooling, conditioning, storing, handling, cleaning, washing, waxing, sorting, sizing and packing deciduous fruit and tree nuts. The research is carried on by the Wenatchee, Wash., and Athens, Ga., field offices and by the Washington office; in both laboratory and commercially-owned facilities,

in the Pacific Northwest, the New York-New England area, the Appalachian area, Georgia, and Michigan, in cooperation with the Washington, West Virginia, Maine, Georgia, and Michigan Agricultural Experiment Stations, the New York State Department of Agriculture, and the Market Quality Research Division, AMS. The work involved 2.8 Federal professional man-years in F.Y. 1962.

Work on improved consumer packages and shipping containers is carried on in cooperation with the State Experiment Stations of Georgia and South Carolina; at AMS branch field stations in Fresno, Calif., and Yakima, Wash.; and in cooperation with grower-shippers of pears in California, Oregon, and Washington; of apple grower-shippers in Washington State; of plum and grape grower-shippers in California; of sweet cherry grower-shippers in Oregon and Washington; of peach grower-shippers in the Southeastern States and of the suppliers and the terminal market receivers of these fruits in various major U. S. cities. This work utilized 3.3 Federal professional man-years in F.Y. 1962.

Pallet containers were tested with the cooperation of Washington State apple grower-shippers and Minnesota chain store prepackaging plants. The work utilized .5 Federal professional man-years in F.Y. 1962.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The related research of the State Experiment Stations was not reported by commodities and is included in other reports. Virtually all of the USDA work is done with industry cooperation or participation and involves trade associations, equipment and supply manufacturers, and others mentioned above as cooperators.

Most of these industry members are interested in a wide variety of commodities. Professional man-years involved in their research efforts are not available for specific commodities. For summary statements for research on all commodities, see pages 46-47, 89, and 102-103 in the Transportation and Facilities report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Handling and Packing Deciduous Fruits

This research is directed toward more efficient work methods and equipment for handling and packing apples; including the adaptation of the results of the previously completed research to the handling and packing of McIntosh apples.

1. In the New York-New England area data were collected which will permit comparison of the four major types of packing lines used in this area. These packing lines account for over 90 percent of the fruit packed, and consist of the following combinations of equipment: (1) A drum dumper, float-roll sorting table, dimension sizer, and return-flow belt; (2) an automatic dumper, roller sorting table, weight sizer, and return-flow belt; (3) manual dumping, chain sizing, and packers sorting from a return-flow belt; and (4) an all-manual sorting-sizing-packing operation. The data collected were mainly with McIntosh variety apples. The material has been analyzed, and the results of this study published in Marketing Research Report No. 543, "Packing Apples in the Northeast."

The report shows that an all-manual method in which one worker sorted, sized, and packed from field lugs had the lowest combined labor and equipment cost of 13.7 cents per packed container when the wage rate was \$1.25 per hour and 50,000 crates were dumped annually; manual dumping with chain sizing had the highest cost at 20.9 cents per container. The packing line using a drum dumper and dimension sizer had the lowest labor cost, 10.0 cents per container; the line with manual dumping and chain sizing had the highest labor cost at 16.5 cents per container.

Fruit from the all-manual line was generally less uniform in size and quality than that from the mechanized lines, but this varied with the skill and experience of the workers. Probably the biggest disadvantage of the all-manual method was its great dependence on a relatively large, well-trained, productive crew of workers, also, the difficulty of increasing volume because of the greater space requirements of this method.

2. In Michigan studies also were devoted primarily to the McIntosh variety. Time studies were made of cell-packing and bagging operations. The dumping of apples into water from both pallet boxes and field lugs was also studied. A large amount of bruising was observed on the apples as they left the dump tank. The advantages of handling and storing most varieties of apples in pallet boxes have been proven, but this method will be feasible for McIntosh only when the quality of the fruit can be maintained.

Preliminary tests were conducted in which McIntosh apples were presorted, presized, returned to pallet boxes, and placed in C.A. storage. During the test, enough low-grade apples were removed at the time of sorting to make available about 25 percent more storage space for the marketable fruit. This gain in storage space was accomplished, however, at a high cost in bruises and stem punctures--over one third of the apples of the McIntosh variety being damaged enough to lower their quality by one or more grades.

As existing equipment proved unsuitable for presorting and presizing McIntosh apples, preliminary designs were prepared for new equipment that provides for dumping the fruit in water and for the sorting and sizing of the apples while they are still in the water. Under a cooperative agreement with the Michigan State Station research has been initiated to do the final design work, construct a prototype, and test equipment which uses water as a medium for dumping, sorting, sizing, and filling fruit back into pallet boxes.

3. Marketing Research Report No. 550, "An Automatic Pallet Box Filler for Apples," published in September 1962, presents the results of research on designing, constructing, and testing an item of equipment for automatically placing apples into pallet boxes.

B. Storage of Deciduous Fruit

1. Cooling Rates. The purposes of this research are to: (1) Measure and evaluate the cooling rates of fruits in storage and shipping containers in terms of container designs that properly protect the fruit, shorten the cooling period, and maintain the fruit at proper storage temperatures and (2) develop improved handling, stacking, and storage practices.

Cooling rate studies of apples packed in vented fiberboard boxes conducted during the 1959-60 season, in cooperation with the Horticultural Crops Branch, MQRD, AMS, were completed and an article prepared and published. These tests, although quite lengthy, did not establish the optimum means of venting fiberboard boxes. However, they did prove that the present commercial method of venting fiberboard boxes does not markedly increase the cooling rate over nonvented boxes.

A cooling study of apples packed in fiberboard boxes, using full wrap and both perforated and nonperforated trays, was made in a storage under regular commercial conditions. The test showed that there was practically no difference in the cooling rate between the two types of packs, which was to be expected as the paper wraps on a full wrap pack have a tendency to close off any air circulation passages. This is in agreement with earlier tests made in the laboratory.

Spot checks were made of apples in three different storages in various types of containers to determine the core temperature of the stored fruit. In most cases, the core temperature of the fruit checked closer than 1⁰ F. to the room air.

Work was done on the cooling of packed cherries stacked on pallets using the chimney stack method in which the lugs are arranged so as to leave a hole up through the center of the stacks. In one test run the cherries cooled only 5° F. in 18 hours when the average room air was 31° F. Because of this poor cooling rate, the chimney method of stacking was immediately abandoned for a more desirable method.

A cooling study was made of cherries packed in a gift package consisting of a chipboard box containing 5 pounds of Bing cherries. These packages were precooled to 35° F., then mailed to various locations. Because of the longer time anticipated for the gift packages to reach their destination, the cherries were in very poor condition on arrival. Judging from simulated shipments in which the packages were held in the Wenatchee laboratory at room temperature, 4 days would be a permissible shipping period for the type of gift package used in these tests.

A cooling study of pears packed in fiberboard containers and standard wood lugs was conducted in a commercial cold storage plant but the data obtained were of little value because of the handling and movement within the storage of the fruit during test. However, the test does indicate that the cooling rate of pears packed in fiberboard containers is essentially the same as pears packed in standard wood lugs. After ten days storage the fiberboard containers stabilized at a temperature 0.2° F. higher than the standard wood lugs.

A cooling study was conducted of apples packed in fiberboard containers and stacked in two different methods on pallets. The loose stacking method resulted faster cooling of the apples and a lower stabilized temperature.

2. Refrigerated Storage. The objectives of this project are: (1) To investigate airflow and distribution methods, patterns, and rates in refrigerated fruit storages to determine and evaluate the influence of these factors on cooling fruit and on bringing it to optimum storage temperatures; (2) to determine and evaluate heat gains through various structural features of fruit storages and make suggestions for improved designs; and (3) redesign storage houses for the most efficient handling and storage of fruit in pallet boxes.

In order to facilitate the movement of pallet boxes and pallet loads of apples into and out of a cold storage house, an air door, or air curtain, was designed, installed, and tested at a commercial apple storage plant in Wenatchee, Washington during 1960-61. This air door gives a clear and unobstructed view through the door opening at all times. The air door effectively sealed the entrance and acted as an insulating curtain. It eliminates the need for swinging or sliding doors. The report entitled "Air Door for Cold Storage Houses" was published.

Periodic checks were made at three storages to measure the difference in air temperatures between the stored fruit in pallet boxes and in fiberboard boxes. The humidity was checked at the same time with a sling psychrometer. These storages were of 25,000-, 55,000-, and 145,000-box (loose fruit) capacity. Cold storages using ammonia cooling systems were able to raise their humidity by increasing the back pressure to the compressors. The relative humidity was raised to 85 percent or better in these storages. Storages using Freon for a refrigerant and having a minimum amount of coil surface could not change their system back pressure to effectively raise the humidity. Buckets of water were splashed in the aisles on the floor each day which improved the relative humidity to a satisfactory level of 80 to 85 percent. The research indicates that humidifiers should be installed in these storages to overcome inadequate coil surface.

During the erection of a steel-type cold storage warehouse near Orondo, Washington, thermocouples were placed in the ground under the concrete floor slab, in the walls, and in the ceiling. Periodic temperature readings have been taken from these thermocouples during the past season. These readings will be used in calculating the insulation value of the various components of the building.

Because of the lack of facilities for conducting needed tests, research to develop a method for improving the cooling rate of fruit by varying the static pressure on the room was discontinued.

One storage which was checked for air distribution temperatures, showed that temperatures in various locations ranged from 29.6° to 33.3° F. The relative humidity was 85 percent.

In a cold storage house at Chelan Falls, Wash., which contained four separate rooms, a complete check was made on the storage temperatures of the apples throughout the storage season. Temperature readings were taken weekly from 43 thermocouples installed at various places in the storage rooms. Some of the thermocouples were placed directly in an apple in the center of the boxes to record the fruit temperature and other thermocouples were placed in the adjacent air. Only selected apples, of the quality that would be placed in a C.A. room, were placed in this storage.

In cooperation with the Horticultural Crops Branch, MQ, apples from the same lot were placed in C.A. rooms at the Wenatchee laboratory for a comparative study.

Apples at the Chelan Falls storage were examined on January 8, February 23, and April 11, for pressures and keeping quality and found in excellent condition. In one room of the storage house, which did not cool properly, the fruit was ripe by the first of February. The other three storage rooms had good temperature control and the fruit was in excellent condition when sold in late March and April. Prices received for this fruit was exceptionally good and, in most cases, equaled that received for C.A. fruit. The relative humidity was maintained at 85 percent. This was accomplished by placing tubs of water in the storage rooms and using burlap as a wicking in the tubs. The water was kept from freezing by adding salt.

This test also showed that thermometers in the center aisles or at the ends of a storage room do not indicate the true temperature of the stored fruit.

The manuscript for the report on "Apple Packing and Storage Houses--Layouts and Designs" was completed and submitted for Department publication.

C. Controlled Atmosphere Storage for Apples

Work on this project is designed to develop improved methods, techniques, equipment and facilities for the controlled atmosphere (C.A.) storage of apples in the Pacific Northwest.

Current controlled atmosphere storage studies carried on in the laboratory in cooperation with the Horticultural Crops Branch, MQ, were designed to determine the importance of the following factors and procedures in obtaining optimum C.A. storage of apples: (1) Maturity of fruit at harvest; (2) time interval for lowering oxygen content to the 5 percent level, as required by law in the States of New York, Michigan, California, and Washington; (3) period of time apples might be held in 31° F. regular storage before they are placed under C.A. conditions and still benefit from C.A. storage; and (4) various levels of oxygen and carbon dioxide.

In conducting these tests during 1960-61, apples picked at three different maturity dates--140, 150, and 160 days from full bloom--were packed and placed in the two C.A. laboratory test rooms. The oxygen level in each room was reduced to 3 percent. The CO₂ level in one room was maintained at 5 percent and in the second room at less than 1 percent. The CO₂ was removed from the room atmosphere by bubbling the air through a solution of monoethanolamine, which absorbed this CO₂. When the CO₂ level started to rise, the monoethanolamine solution was replaced and the used solution rejuvenated by heating and driving off

the absorbed CO_2 . The temperature of the rooms was maintained at 30° to 31° F. Apples removed from the C.A. rooms on April 11, 1961 showed a somewhat higher pressure test than the check lot that was held in regular cold storage at 31° F. However, after being at 70° F. for 18 days to test their shelflife, the C.A. fruit generally showed a lower pressure test than the check fruit, the only exception being the 160-day fruit held in the room with less than 1 percent CO_2 . The average dessert quality of the fruit judged by a test panel generally showed C.A. held fruit to be better than the check for Delicious apples, however, the panel rated Golden Delicious apples held in regular storage higher than that held in C.A. storage. These tests have not been conclusive and need to be continued.

Experimental equipment was designed, built, and tested for burning the oxygen from the air in a C.A. room. The oxygen level was lowered very rapidly by this method but at the same time the carbon monoxide gas was raised to an undesirable level. The tests were discontinued because of this generation of carbon monoxide gas.

Apples from the same lot of fruit stored in a commercial storage at Chelan Falls, Wash., were stored in the C.A. rooms at the laboratory in Wenatchee. In both cases, this fruit was selected for the best quality and maturity. Results indicated that fruit stored in properly managed regular commercial storages is equal to C.A. stored fruit. Samples from the C.A. rooms tested on January 24, 1962 tested 15.2 pounds. The highest average pressure on C.A. fruit was 15.2 pounds, and on the regular commercial storage fruit - 15.2 pounds.

D. Cooling Deciduous Fruits

This research is designed to develop improved methods, equipment, operating practices, and techniques for use in existing or new facilities for more efficient cooling of deciduous fruits.

Data on thermal conductivity of separate components of fruits were compiled and analyzed.

Laboratory tests were carried out to establish values of the "effective" thermal diffusivity of whole specimens of nine varieties of peaches to determine if, and to what extent, the heat transfer characteristics vary among varieties and among various stages of maturity within varieties. These data have not been completely analyzed, but preliminary analysis indicates that there is a statistically significant difference among some varieties and maturity. However, it is doubtful whether these differences in thermal diffusivity are of practical significance.

Tests were conducted to compare the use of a wetting agent with no wetting agent in the water for hydrocooling peaches. Experimental evidence suggests that, under the conditions tested, introduction of a wetting agent does not increase the rate of cooling.

Studies to obtain hydrocooler performance data were carried out in six packinghouses in Georgia and South Carolina. Although existing hydrocoolers generally are effective in removing field or harvest heat, their performance from the standpoint of economy is poor.

Hydrocooling studies were made during harvest at an apple packing plant in Washington where a hydrocooler was set up for commercial operation. The temperature of the cooling water was 37° F. Fruit was in the hydrocooler for 16 minutes. An apple with an initial core temperature of 71.4° F. when run through this hydrocooler had a final core temperature of 68.5° F., or a drop of only 2.9° F. However, the temperature of the apple 1/2-inch under the skin was 56.5° F., or a drop of 14.9° F. This 1/2-inch layer represents about 70 percent of the volume of a 3-inch diameter apple. Because of mechanical difficulties with the cooler complete studies could not be made.

Test apparatus designed for determining the thermal conductivity of separate components of fruits and vegetables was repaired and modified to meet the needs imposed by the test materials. A technical paper dealing with the design, development, and standardization of the equipment and test procedures was submitted to the ASHRAE Journal for publication.

First and second drafts of a manuscript for a technical bulletin entitled "Principles and Methods for Hydrocooling Peaches" were completed and submitted for administrative clearance.

Plans were formulated and preliminary test runs were initiated to determine the film coefficients of heat transfer from the surface of individual or bulk fruits and vegetables to air as a cooling fluid. The fabrication of a wind tunnel to further pursue these studies is currently underway. Results indicate that the experimental technique is sound and that the values of surface conductance obtained experimentally compare favorably with values calculated by use of theoretical relationships.

During the summers of 1961 and 1962, cooling tests were run on gift packages of cherries insulated with 1/4-inch of plastic foam material, 1 inch of styrofoam, and 2 inches of styrofoam. The purpose of the insulation was to prevent the cherries from warming up too fast during shipping by mail after being precooled. The rate of warm-up of the 1/4-inch insulated package over the standard uninsulated package was not sufficiently retarded to warrant its use. However, both the 1 inch and 2 inches of insulation showed substantial delay in the warm-up time.

Starting at a temperature of 32° F. for the cherries and a room temperature averaging 82° F., the standard gift pack of cherries reached 60° F. in 8 hours. Under the same conditions; 1 inch of styrofoam gave a warm-up time of 14 hours and 2 inches of styrofoam a warm-up time of 18 3/4-hours, or a delay in a warm-up time 177 percent and 204 percent, respectively, over the standard wrap gift package.

E. Handling Grapes in Pallet Boxes

This research is directed toward developing improved work methods and equipment for handling Concord grapes at processing plants.

During the 1960-61 season time studies were made at one processing plant of handling operations in which field lugs were used. These operations included: (1) Positioning loaded truck or trailer, (2) unloading full lugs from carrier, (3) dumping grapes from lugs, and (4) stacking and loading empty lugs. To assure a continuous flow of grapes into the processing system large receiving and box-loading crews were maintained, at a high labor cost, for lug handling.

Preliminary data show that pallet boxes could be used in lieu of lugs for handling grapes and might reduce the labor requirements for handling by about 75 percent.

Because of the very short grape crop in Michigan in 1961 (about one-half the production in 1960) no grapes were available for experimentation. As a result no work was done on this program during the 1961-62 season.

F. Consumer Packages and Shipping Containers for Deciduous Fruits

1. Pears. After three years of work seeking the development of an attractive package that would adequately protect highly perishable pears in transit, researchers believed they scored a breakthrough in the 1960-61 season. The successful package was a shallow tray with a band of biaxially oriented polyethylene film shrunk tight over 4 to 8 pears. Thus immobilized at point of production, Anjou pears in the experimental packages sustained less than 1 percent total bruising in a series of test shipments as compared with 23.5 percent bruising in standard wood boxes. Discoloration of Anjous in the new packages was 4.5 percent against 6.9 percent in the wood boxes. During the 1961-62 marketing season four Oregon and Washington shippers adopted the new package for commercial use as compared with one shipper the previous season. Continuing research has been successful in a steady reduction of packaging costs, ranging from 16 to 28 cents a box, depending on size of fruit. Shallower and less expensive pulpboard

trays and a deeper master container that had a capacity of 5 or 6 layers of 5 packages, instead of only 3 layers, were developed. All layer pads were eliminated because the shrink film immobilized the pears so that it was not necessary to obtain compression of the entire pack. Perhaps the most significant result of this research was that pears packed at harvest time and held in storage for several months could be delivered to distant markets in almost perfect condition. The receivers were particularly impressed with the excellent arrival condition. They thought the packages were attractive and would do much to increase pear sales in the retail stores. Package appearance at retail, while good, was not what it might have been because of occasional loosening and wrinkling of film wrap, due in part to use of imperfect shrinking techniques at the packing plants, and possibly in part to shortcomings of the film itself. Since the retailers normally prepackaged their pears before selling them, they were familiar with the extra costs involved and appeared to be willing to pay a premium to cover these costs.

Evaluation of experimental shipping containers and packaging materials for Anjou pears was undertaken to assist the industry in developing less expensive packs than the standard wood box. The experimental packs tested were: (1) Polyurethane place-pack, and (2) the tray-pack conventionally used for apples. Place-packing pears with a polyurethane pad between layers permitted the use of smaller lighter, and less expensive fiberboard containers resulting in savings of 4.1 cents per box, or \$38.05 per carload of 928 boxes. Many pear shippers who are also apple shippers liked the economies of using apple pulpboard trays for pears to permit the use of a single size master containers for both commodities. Lower packing labor and shipping costs permit savings of 1.25 cents a box, or \$11.60 per carload. Terminal inspection of 5 full-carload commercial rail test shipments and 8 controlled shipments containing experimental and standard boxes indicated that use of both types of experimental packs resulted in significantly less bruising of pears than in the wood box.

2. Apples. The development and evaluation of consumer packages, master containers, and methods of packaging medium to large size apples at point of production have resulted in a consistent reduction in costs. Material costs per box of 16 packages of 8 group-size 125 apples was 88 cents during the 1959-60 season; 78 cents during 1960-61 season; and 67 cents during the 1961-62 season. Also, development of new wrapping methods which greatly increased the efficiency of the workers reduced the direct cost of labor to pack the apples from 23 cents to 17.5 cents a box between the 1960-61 and 1961-62 seasons. Examination of 15 commercial test shipments of packaged apples indicated that the Red Delicious apples generally arrived at destination in excellent condition. However, it was found that the conventional between-layer pad was not able to protect soft fleshed

Golden Delicious apples from bruising. Researchers developed a box with vertical separators, as well as horizontal pads, which sharply reduce injuries. Although the film-wrapped packages arrived at the terminal markets with a fresh, attractive appearance, some films tended to wrinkle and discolor before they were purchased by the consumer, possibly as a result of warm temperatures and the more rapid emission of esters during this period. In most cases discoloration was slight and did not affect salability.

Evaluation of less expensive cushioning materials for use in shipping apples was conducted in a series of laboratory tests simulating transit conditions. New expanded polystyrene was tried as both a between-layer pad for place packed apples and as a molded shipping tray with pockets similar to those in conventional pulpboard trays. Earlier studies indicated that polyurethane pads, in the thickness and density used were not a satisfactory cushioning material. Its cost prevented going to a heavier material. Less expensive polystyrene was contributed for evaluation by a number of manufacturers. All types initially submitted broke or shattered under simulated transit conditions because of the brittle character of the material. Suggestions for improvements were reported to the manufacturers who redesigned and modified their pads and trays. In each succeeding test breakage was reduced but not eliminated. Eventual success is anticipated in the development of pads and trays that will reduce transit injury of apples at a cost competitive with conventional materials.

3. Peaches. A consumer package developed by researchers, a fiberboard box newly come on the market, and the conventional tub basket were combined into a "family" of containers to observe their potential as a means of maximizing sales of peaches and returns to the growers. Package differentiation permits the marketing of a commodity in containers most suitable for particular sizes or qualities, and most profitable in particular segments of the consuming markets. The prices received for any one type of container are not as important as getting the highest average price for the whole crop of peaches. The consumer package was a 4-pound till of green pulpboard holding 18 to 20 uniformly sized small peaches overwrapped with transparent film at point of production. The larger peaches were packed two layers deep in cupped trays in a shallow fiberboard box. Peaches in a range of sizes were packed in the conventional 3/4-bushel basket. At retail, the small, uniformly sized packaged peaches in the fiberboard box sold for 17 cents whereas peaches in a range of sizes in the basket sold for 10 cents. At shipping point a premium was received for the larger peaches, and the price of the prepackaged peaches was enough higher than the price of the basket peaches to pay for the additional cost of materials and direct packaging labor. Shoppers who paid more for the small packaged peaches and the larger peaches in the tray pack received fruit that was in

better condition. Upon arrival in terminal markets, total bruising in the packages was 3.3 percent, in the tray packs 7.2 percent, and in the baskets 13.5 percent.

In an effort to lower costs and to deliver peaches in better condition to consumers, a number of new shipping containers were evaluated. These included several new types of 3/4-bushel fiberboard boxes holding approximately 38 pounds, as well as a combination 3/4-bushel wire-bound and fiberboard box, and a new type of flat top 3/4-bushel basket. The new 3/4-bushel basket was designed to be volume-filled or face-packed. The combination fiberboard and wirebound box appeared to be the best of the new containers. It was about 3 cents cheaper than the bushel baskets and it was cheaper to pack. This increased the returns to growers. It carried the peaches well with little bruising. It was sturdy, well ventilated, and was generally well liked by the receivers except for the quarter-telescope fiberboard lid which wasn't sturdy enough. Forty of these boxes can be stacked on a pallet in the warehouse which generally holds only 30 bulge-packed 3/4-bushel baskets.

4. Grapes. Bulk grapes are subject to considerable waste and spoilage losses resulting from customer handling of retail displays. Store operators want to buy prepackaged grapes but shippers are reluctant to package because of higher costs. A redesigned window carton with a stapled recessed bottom and holding 1-3/4 pounds of grapes reduced packaging materials and labor costs 1.1 cents per pound as compared with the costs of earlier packages. Subsequent experiments were conducted with 2-pound capacity plastic baskets overwrapped with polystyrene and oriented polyvinyl chloride shrink films and compared to a slitted polyethylene overwrap that was being tried by several California grape shippers. Preliminary work on wrapping methods and two rail test shipments to eastern markets indicated that the shrink film overwrap would significantly decrease labor costs and, at the same time, enhance the appearance of the package. Other preliminary work on the packaging of individual grape bunches shows considerable promise. It would eliminate the labor of cutting up the bunches as it is now done for the rigid packages; it would "show off" the natural beauty of the grapes; it would permit the sale of the grapes on a catchweight basis, which many retailers think is advantageous for products such as grapes.

Four experimental shipping containers for grapes were evaluated in comparison with the conventional lug in a series of exploratory test shipments. California producers want a low cost container that will reduce transit and handling damage. A one-piece 28-pound fiberboard box with wood frame ends turned in the best performance with total bruising and shattering of only 0.9 percent. Grapes in an 18-pound box of a similar type sustained 2 percent bruising and shattering, the same as in the conventional lugs. The box with the best

performance was the only experimental container costing less than the conventional lug.

5. Plums. Two types of consumer packages were studied. The first was a folding carton with cellulose acetate film window and a stapled-recessed bottom; the second was a shallow pulpboard tray overwrapped with various types of plastic films. The cost of packaging materials for the experimental packages ranged between 1.9 and 2.5 cents per pound, as compared to the cost of 1.9 cents per pound for the conventional 4-basket crate. Prepackaged plums in four rail test shipments from the San Joaquin Valley to two east coast markets arrived in good condition and were well received by the retailers.

6. Apricots and Prunes. Apricots and prunes were test packaged in 1-quart pulpboard tills which were packed 12 in a single layer in a full telescope fiberboard box. The 12 tills were volume filled to a total net weight of 26 pounds. Material costs were 41.6 cents a box. Preliminary test shipments to eastern markets indicated that a rigid package, such as the till, was more desirable than a film bag. However, some tills absorbed moisture and lost rigidity and shape.

7. Cherries. Bing cherries were experimentally prepackaged by volume filling them in new 1-pint plastic baskets which were packed 12 to a single layer in a wood master container with a fiberboard cover. The baskets were not covered but vented polyethylene sheets were enclosed for covering the baskets after they reached retail level. The baskets protected the cherries very well and were popular with produce managers in the stores. However, some master containers were damaged and the film sheets provided as basket covers were unsuccessful. They were too easily dislodged. Most stores substituted an oversize sheet of cellophane held in place by a rubber band. In the season following the tests, one shipper successfully marketed eight carloads of the pint-size cherry packages in slightly stronger nailed wood flats.

G. Improved Loading Methods for Truck Shipments of Apples in Corrugated Fiberboard Containers

All field work on this projected was completed about two years ago. The initial results of this research were summarized in an interim report, AMS-321, entitled, "Loading Methods for Truck Shipments of Apples in Fiberboard Boxes," released in July 1959.

This work involved the informal cooperation of the Maine Department of Agriculture, the Maine Agricultural Experiment Station, several New England apple shippers, three chain stores, a large truck line, adhesive manufacturers and various other concerns. The interim report described the new "air-channel load" developed in the initial phase of this work and reported on its comparative effectiveness in reducing load disarrangement, container damage and in facilitating more effective refrigeration in transit. Subsequent work described in the final report on this research now being readied for publication centered on the development of improved load securing methods, and materials, including load-locking devices, bracing frames and a frictionizing coating applied to the outside surfaces of the boxes to assure that each container in the new "air-channel load" would remain in place during transit.

H. Pallet Containers for Shipping Apples

Several test shipments of apples in expendable corrugated fiberboard pallet containers were made from Washington State to Minnesota chain store prepacking plants during the past year. Data on comparative handling costs and fruit bruising were obtained to supplement that developed in previous work in this area conducted under contract by the Food Industries Research and Engineering. The additional information obtained in the tests has been integrated with that developed in previous work and a report on this research has been prepared for publication.

This work has shown that savings in shipping apples from Washington State to Minneapolis in pallet containers will amount to as much as \$400 per car as compared to shipping them in the conventional 40-pound tray pack cartons. Savings are derived from lower container, packing, handling, transportation and protective service costs per pound of fruit transported. The pallet containers carried about 800 to 900 pounds of fruit and were loaded, unloaded and handled with fork lift trucks. Savings in transportation costs in rail shipments derived from lower freight costs because increased load density in pallet container shipments made it possible to ship more fruit per car.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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IV. ECONOMIC RESEARCH

ECONOMICS OF MARKETING

Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural economists, economists, and personnel with dual economic and technical training engaged in research to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. This research covers all economic aspects of marketing from the time products leave the farm until they are purchased by ultimate consumers. It includes work on market potentials for new products and new uses; merchandising and promotion; economics of product quality; marketing costs, margins and efficiency and on market structure, practices and competition. In fiscal year 1962, 8.6 Federal professional man-years were utilized in this work.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Most of the Experiment Stations in the deciduous fruit and tree nut growing states devote research resources to investigating various of the phases or areas in the field of economics of marketing, but information is not available by commodities on the professional man-years involved. The same situation holds true for the research by industry in this field.

Industry and other organizations including food manufacturers, industrial firms, producer associations and State agencies conduct or sponsor important research on new products and new uses. Most food manufacturers regard market potentials research as a necessary adjunct to their research and development programs for new food products. Among those industrial firms which process and market agricultural products most key firms have or retain competent research and development organizations. Results of these market research efforts mostly are kept confidential. Several producer associations sponsor research on development of new food products and contribute to the early stages of commercial trial and evaluation of these products.

Research on merchandising and promotion of deciduous fruit and tree nuts is in progress in New York State, the Southern region, Puerto Rico and Hawaii. Industry and other organizations including voluntary producer-promotion groups; commissions, councils, boards, etc., established under enabling legislation; wholesalers and retailers; processors and distributors; State Department of Agriculture, and individual proprietors, also conduct some research on merchandising and promotion. Both private firms and agricultural promotion groups do contribute to public research in this area by cooperating with the Department. They provide facilities (which are essentially laboratories), personnel, office space and economic data to the USDA program. The agricultural promotion groups cooperating with the Department finance all merchandising and promotional cost involved in cooperative research studies and frequently contribute financially to the research by defraying part of the cost of collecting data.

The amount of research conducted by private firms on marketing margins, costs and efficiency is not known but it probably is small.

Many of the Experiment Stations devote considerable research resources to investigating the market structure and practices for the various fruits and vegetables in many producing areas. A description of current practices provides a basis for knowing where inefficiencies are and what obstacles exist to improvement of marketing practices. Another phase of this research deals with the effects which changing technology and practices have upon the availability of markets and returns to the grower. An example of these projects is the study of how large-scale retail buyers operate, what they will expect of farmers in terms of

commodity specifications, and marketing services, and how farmers may be compensated for performance of services, previously the responsibility of other sectors of our production-marketing system. Another element of these studies is the determination of processing and packaging plant location in relation to economy of size of producing area.

The Northeast region is coordinating research in this area under NEM-23, Sales Organization for Marketing Northeast Processed Fruits and Vegetables.

Several states have projects designed to determine the potential market for their products and their cost and price relationships compared with those from other states. California and Georgia are also giving attention to factors affecting optimum locations for processing plants. Oregon is developing information on the costs of items used by the fruit and vegetable processing industry in the Northwest as compared with other regions in the Nation. Three states are completing a project, WM-17, Competitive Position of the Western Region in Marketing Frozen Fruits and Vegetables.

New Hampshire is developing information on prices and distribution costs for apples for 12 regions in the United States. This information, together with production and demand, is expected to show the competitive advantage or disadvantage of each area. Georgia is analyzing the market demand and seasonal pattern of shipment of Georgia peaches in order to determine the most profitable markets.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Market Potentials for Superconcentrated Apple Juice. Relative to other major fruits the processing market for apples appears to be at less than its potential capacity. In cooperation with the Michigan State Apple Commission and the Eastern Utilization Research and Development Division, ARS, a market test was conducted on EU's 7-fold concentrated apple juice to ascertain the potential for this processed product. The results of the market test conducted in Fort Wayne, Indiana, have been analyzed and a manuscript is in process of publication. The product shows excellent promise of commercial success. During the market test, it ranked in the top 10 percent of audited sales among 81 frozen, canned and bottled juices in Fort Wayne supermarkets and far outsold existing single strength apple juices in the test market.

Commercial Possibilities of Dehydrofrozen Apple Slices in Institutional Markets. Data collected from product tests of dehydrofrozen apple slices, a new product of the Western Utilization Research and Development Division, ARS, where there is a 50 percent weight reduction by dehydration and then preserved by freezing, have been analyzed. A final report showing the results of this study is being cleared for publication.

Market Potentials for Hawaii Farm Products. Research in cooperation with the Hawaii Agricultural Experiment Station has been initiated to determine the economic feasibility of broadening the base of Hawaiian agriculture by developing new markets for diversified Hawaii products such as macadamia nuts, and fruits and juices. Market tests will be conducted to introduce Hawaiian products in new markets to ascertain their acceptability and salability and to provide estimates of potential demand to guide market development efforts. Marketing and merchandising practices will be evaluated to determine improvements required for full exploitation of market expansion possibilities.

Economic Impact of Freeze-Drying. New technology can have tremendous consequences and their impacts need to be evaluated with special reference to costs, market structure, labor demand and utilization, capital needs, and market demand. Freeze-drying is an emerging technology of possible major import which requires study to ascertain its place and impact in the marketing system. Since initiation of this newly formed industry, a test panel for existing commercial products was established with the cooperation of ARS at Beltsville. Also, with the cooperation of plants either commercially processing or experimenting with commercial pilot operations, and from representatives of equipment companies, data has been gathered which will form a basis for a synthetic projection of what costs may be anticipated with model plants constructed in the following sizes: 4 tons, 8 tons, 16 tons, and 32 tons of water removable ability for a 24-hour period. Work has been initiated to use such engineering synthetic cost data to estimate the impact of freeze-drying upon food processing industries and in the process to estimate the long-run potential of the freeze-dry industry.

The taste panel work covered approximately 30 freeze-dry products now on the market. Comparisons of current frozen and canned products of standard quality were used as a frame of reference for the testing of the prepared freeze-dried foods. Preliminary results suggest many of the products are satisfactory from a taste standpoint. However, a few appear to be unsatisfactory.

Preliminary estimates imply that the cost per pound of water removed will approximate 7 cents for a low volume capacity operated plant, and about $3\frac{1}{2}$ cents for a large capacity operated plant. A full report of the engineering synthetic costs should be ready for publication during the fiscal year.

Market Potentials -- Liaison Between ERS and Utilization Research, ARS.

An agricultural economist is stationed at each regional Utilization Research and Development Division to provide liaison between the regional laboratories, ARS, and the Economic Research Service in order that economic research may be teamed with physical science research in approaching problems relating to new products and new uses. Phases of

work are as follows: (1) to delineate the economic problems involved in developing markets for new and extended uses of commodities on which the laboratories are working; (2) to develop and assist in carrying out research studies for providing information that would aid the laboratories in deciding what particular products or processes would be most likely to be economically feasible; and (3) to develop and assist in carrying out research studies for appraising new products and processes developed by the laboratories, including studies of market potentials, comparative costs, and studies of the probable impact of new developments on sales and farm income.

Merchandising and Promotion. Studies have been conducted to:

(1) Evaluate the effects of apple promotion, in which two different general themes were used, on sales of apples and competing fruits. The findings of this research revealed that the promotional theme emphasizing the various uses of apples was more effective than the one emphasizing health and nutrition when employed independently. Sales increase over comparable periods of no promotion were 20 and 9 percent respectively for the "apple use" and "general health" themes. The effect of the apple promotion on sales of other fruit was not found to be statistically significant. However, the relationships that were found corresponded to findings of previous research; namely, that practices which increase apple sales also benefit sale of oranges, and that apples and bananas are competitive saleswise. The retail merchandising practices employed with each of the fruits that could be measured in quantitative terms were also analyzed. Of these practices, price and the amount of display space devoted to each fruit exerted the most influence on sales. Sales varied directly with changes in display space and inversely with changes in price.

(2) Determine consumer acceptance of apples as related to percent of good red color. The results of this study showed retail sales of highly colored apples (75 to 100 percent good red color) were significantly greater than partial red apples (50 to 75 percent good red color), or apples ranging from 50 to 100 percent good red color. Sales of the combination of highly colored and partial color (50 to 100 percent color range) were significantly greater than sale of partial colored apples (50 to 75 percent color range). Losses from spoilage and excess handling were less from apples sorted in the narrower color ranges, 50 to 75, and 75 to 100 percent good red color.

(3) Evaluation of the sales effect of various promotional techniques for winter pears revealed that store demonstrations and dealer contests were equally effective as sales stimulants for winter pears as compared to no promotion. Sales increase of 24 and 22 percent respectively were recorded for the two techniques. Media advertising at a relatively low level of intensity, and special point-of-purchase displays were not found to be effective for expanding sales. The success or failure of

these techniques to increase sales was directly related to the retailer support given them in terms of prices, display space, and newspaper advertisement space for winter pears. Retailers devoted greater display area and newspaper advertisement space to winter pears, and featured them at a lower price during periods when store demonstrations and dealer contests were conducted than during periods of no promotion. In contrast, retailers actually devoted less display space and newspaper advertisement space during the media advertising and special display techniques than they did during comparable periods of no promotion. There was only a small difference in retail price between each of these techniques and no promotion.

(4) In addition to the above research dealing with specific problems, a summary of published merchandising and promotion research conducted during the last 15 years on fresh apples in being prepared. This summary and similar summaries of research pertaining to other phases of apple marketing will be combined and released in one publication.

Economic Feasibility of Marketing Radiation Pasteurized Strawberries, Peaches, and Grapes. A study of the economic feasibility of marketing radiation pasteurized products and of the impacts on market supplies, prices, and methods of marketing began in 1962 and no findings are available. This study is being conducted for the U. S. Atomic Energy Commission.

Marketing Costs, Margins, and Efficiency. Packing costs are an important part of total marketing costs for fresh peaches. In California, packing costs for Red Haven and Early Elberta peaches averaged 71 cents a lug in ranch sheds and 73 cents in commercial sheds in 1959. Costs among packing sheds ranged from 65 cents to 81 cents a lug. On the average, packing materials were nearly 60 percent of total costs, labor about 25 percent, and overhead about 15 percent. In South Carolina, total packing costs per container were lowest in small sheds and highest in large sheds regardless of type of container because of higher labor and operating costs. For packing peaches in bushel baskets, the predominant container, total costs per basket were \$1.05 for small sheds, \$1.11 for medium size sheds and \$1.29 for large sheds. However, because differences in costs within each of these 3 groups of plants were greater than the between-group differences the latter may not be significant. This research has been completed and published.

Costs of packinghouse operation are a substantial share of marketing charges for apples. Packing costs can be reduced through increased mechanization of packing, increased plant volume, increased length of season, and some changes in methods of paying packers. In smaller plants, with short packing seasons of 200 hours and a season output of 50,000 tray-pack equivalent units, packing labor and machinery costs for each tray-pack carton can be reduced from 45 to 21 cents by using a semiautomatic tray packing machine. In larger plants that

operate about 1400 hours a season and have an output of 250,000 tray-pack equivalent units, labor and machinery costs can be reduced from 19 to 12 cents per carton of tray packs. Similarly, labor and machinery costs for a carton of twelve 4-pound bags can be reduced from 33 to 26 cents each, while costs for a carton of nine 5-pound bags might drop from 21 to 19 cents each, if semiautomatic bagging machines are used instead of manual methods.

Research concerned with the effects of technical developments on the optimum economic organization for marketing Californian fresh pears has centered on the extent to which in-plant costs in fresh pear packing-houses--including precooling and storage costs--are affected by the adoption of recently developed bulk-fill packing techniques together with the use of bulk bins in assembly, and cannery and cull fruit operations. Cost reductions are possible by shifting from lug-box to the much larger bulk-bin containers in orchard-to-plant transportation but the relative costs of the two containers depend on the handling method used and the rate and length of haul. For low rates of output and short lengths of haul, the lug-box method is cheaper. For higher rates of output and longer lengths of haul, the bin handling method yields lower costs than any lug-box method of handling. However, these cost differences are small. In-plant packing and shipping costs for pears are about \$8.75 a ton lower when the volume-filled carton is used instead of the standard wrap-and-place pack box. The fiber-board containers cost about 25 percent less than the wooden boxes. The combination of plant and storage facilities that minimizes combined plant, storage, and "penalty" costs involved in handling a specified total quantity of fruit delivered to a plant in the seasonal pattern characteristic of plants in the Lake County Region (California) has been established. Penalty costs are the additional costs or reduction in revenue incurred by the firm when it is unable to handle a given day's receipts in the normal fashion. Minimum expected costs and cost savings of over 6 percent are achieved by operating a plant up to 10 hours per day and storing excess receipts for handling later. A manuscript on the final phase of this study is now being reviewed for publication.

In the past 5 marketing seasons, total marketing margins on Washington Delicious Apples ranged from \$6.41 to \$7.06 a box in Chicago and from \$6.17 to \$7.41 in New York City. These margins are in the range of 65 percent to 90 percent of retail prices. Wholesale-retail margins averaged over half of total margins and varied inversely with auction prices. Terminal, transportation, and shipping-point charges averaged about 35 percent of retail prices. Chicago retail prices averaged higher than New York retail prices in 4 of the 5 seasons, but the reverse was true for auction prices. Both retail and auction prices move in the same direction, but retail prices fluctuate less. Auction prices vary inversely with changes in supplies. More detailed analyses are in progress, including studies of margins on other principal fruits and vegetables. An effort is being made to separate wholesale-retail margins into their two major components.

Impacts of Marketing Orders on the Raisin Industry. A study analyzed the economics of the raisin industry giving particular attention to the impacts of market orders on the industry. Findings were reported in the 1960 annual report. A manuscript analyzing the marketing orders for raisins is being reviewed for publication as a technical bulletin.

Market Structure, Practices and Competition. The wholesale fruit and vegetable business is a static industry in the midst of a dynamic economy. The total volume of fresh fruits and vegetables for off-farm civilian consumption increased 12 percent from 1935-39 to 1957-61, while the total volume of all food was increased nearly 60 percent. Direct buying from shipping points by chains and other retail organizations has increased sharply, and the total volume of business of wholesalers has declined. The number of major wholesalers is declining. These changes in structure create severe strains within the industry both at the wholesale and the shipping point level. Their impacts on farmers, in terms of the demands for their products (quality, uniformity, packaging, quantity, etc.) are marked. Wholesalers, packers and shippers, and farmers will find it increasingly necessary to make adjustments to the different types of buyers with whom they must deal and their requirements.

Recent technological developments have had tremendous impacts on the organization and practices of the California fresh deciduous fruit industry. A survey of the fresh deciduous fruit packers was completed in August 1961. As expected, differences were found among the types of firms and those handling the various fruits. Cooperatives in California handle about 16 percent of the total volume of fresh deciduous fruits, but they handle about 64 percent of the pears. Grower-shippers handle about 65 percent of the total volume, but they handle almost 80 percent of the table grapes and over 80 percent of the apples.

Procurement arrangements between packers and growers are highly informal, unless production credit is involved, but relatively little such credit is extended by packing firms. Cooperatives all use some type of marketing contract, but these seldom are rigidly enforced.

Approximately 52 percent of California fresh deciduous fruit is sold through some type of sales agency; the balance is sold by individual packing firms. About 15 percent of the packing firms use bulk (size) pallet bins in some part of their operation. Only 8 percent of the firms pack deciduous fruit in consumer-size packages.

Analysis of the survey data indicate that the acreage of the various major types of deciduous fruits in California is likely to expand as much as 25 to 43 percent by 1975. The State's share of total United States production has increased about 10 percent since the 1920's, and this trend is expected to continue. The location of production within the State is shifting, largely due to the sharp increase in the acreage of these fruits in the San Joaquin Valley as compared to other areas. There is evidence of an increase in the size of farms, especially in the Central Valley. The major utilization trends observed are the increasing emphasis on processed forms of these fruits and the dramatic decline in their per capita consumption, especially in the fresh form, during the past few decades. The fresh marketing sector seems to face two major types of problems in its adjustment to these changing conditions. These involve increasing marketing efficiency and maintaining or improving competitive position. Two types of relatively new handling techniques--bulk filling of containers and bulk-bin handling--should aid in increasing efficiency through lower container costs per pound of fruit and decreased packing expense.

Prepackaging by California firms at shipping-point has not been generally satisfactory. However, the cost of repacking into consumer-size units at market centers seems to be excessive, especially in view of the cost of initial shipping-point packing using traditional methods. Hence, the combination of bulk-packing at shipping point with prepackaging at the market may be feasible.

Analysis of the impacts of these new techniques are a part of the studies that are continuing on this project. Field work has been completed for a study of the costs of packing peaches in different types of containers. This study will concentrate on a comparative cost analysis of new sizing and filling equipment, styles of containers, and methods of filling in relation to plant size and length of season.

Research in cooperation with the Michigan Agricultural Experiment Station is designed to obtain new types of market information to study price relationships, to determine costs of producing and processing and to project the most efficient future patterns of production and distribution for the tart cherry industry. Progress has been made in each of these areas except projection of production and distribution patterns. This will follow completion of other aspects of the study.

This study indicates that the long-run tart cherry equilibrium price is much higher than the average price received in recent years. Preliminary results of a study of the costs of producing tart cherries in the three major Michigan producing areas indicate a range in these costs of 5.45 to 6.19 cents per pound. Close cooperation has been maintained with the New York and Pennsylvania Agricultural Experiment Stations in a concurrent study to insure comparability of results. In-plant studies of tart cherry processing have been made to develop labor and equipment production standards which will be used to estimate processing costs.

The objectives of studying market structure and practices of the pecan industry are: (1) to evaluate the present system of marketing pecans; (2) to determine marketing costs; and (3) to suggest means of increasing marketing efficiency. In the spring of 1961, all of the 80 shellers and processors were interviewed through the Pecan Belt, and in St. Louis and Chicago. Eight of the firms handle almost 50 percent, and 37, or slightly less than half of the firms handle 90 percent of the total sales of shelled and in-shell pecans to commercial outlets. Bakeries and bakery suppliers are the largest outlet for shelled pecans, using approximately 38 percent of the total. Confectioners purchase 20 percent, while almost 20 percent are sold through wholesale and retail grocers. Nearly all of the in-shell pecans are sold through grocery outlets.

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IMPROVING MARKETING OPERATIONS THROUGH
RESEARCH WITH FARMER COOPERATIVES
Marketing Division, FCS

Problem. Farmers, in marketing their production, face a revolutionary change in terms of market organization and marketing practices. The ever increasing and important supermarkets require large quantities, good quality, and frequent delivery which the small farmer, working alone, or a cooperative, or local firm of limited size cannot supply. Cooperatives must find ways to consolidate volume, either through internal growth, merger, acquisition or federation to help them meet the needs of mass merchandising. Ways must also be found to reduce marketing costs by increasing efficiency through improved operations, better organizations, and more mechanization.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting the farmers' marketing problems in the modern distribution system. They are organized and operated to increase farmers' net income. Through cooperatives farmers seek to increase their bargaining power; obtain needed services at cost; improve the quality of farm products; and obtain a larger share of the consumer's dollar. Cooperatives face many problems in achieving these objectives. Research is needed which will assist marketing cooperatives, as well as other marketing agencies, solve their problems by making available essential factual information and developing practical and useful operating plans and procedures.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operations, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms.

The number of Federal professional man-years involved in this work for all commodities totals 24.8, of which 1.0 is devoted to deciduous fruit and tree nuts.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

In 1961 the State Experiment Stations reported no work in this area.

The majority of the research work of marketing cooperatives is in the area of merchandising and promotion, although some cooperatives are studying feasibilities of having products graded and packed on the farm. Some farm supply cooperatives have formalized economic research departments, and part of their programs are concerned with the marketing of farm products. A few cooperatives now have employed management consultants to study and advise them on organizational and personnel problems.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Improving operating methods. A case study analysis of a blueberry marketing cooperative pointed out that lack of attention to good management practices had allowed many individual problems to develop in various phases of the total operation. In addition to recommendations on specific problem areas, stress was placed on the need for attention to the management function.

Cooperative bargaining. Work is underway to determine some of the effects the bargaining type cooperative has on growers and other segments of the processed fruit and vegetable industry, and to provide guides to growers and others in evaluating the potentials of this marketing method.

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ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Div., ERS

Problem. Adequate and accurate information is needed on supplies, production and consumption of farm products, and the effects these and other factors have on the prices of agricultural commodities. Such information is needed in planning operations for the producers, processors and distributors and also benefits the consumer in selecting his purchases. Similarly accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products are needed by Congress and the Administrators of farm programs to effectively evaluate current and future price support and production control programs.

Due to the instability of the prices he receives, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The farmer needs to be provided with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook intelligence and the development of longer range projections of the economic prospects for the principal agricultural commodities.

USDA PROGRAM

The current emphasis in the field of supply, demand and price is on demand and price analysis for peaches. The study includes analyses which measure statistically the influence on prices of available supplies of different types of peaches, consumer income, supplies of competing products, and the carryover stocks from the previous season. An attempt is being made to find statistical techniques which allow for the joint interaction among prices and different end uses such as fresh market, canning, drying, and freezing. Because of the substantial changes in utilization trends in recent years, these interactions are difficult to measure. This work involves 1.0 professional man-years located in Washington, D. C.

The outlook and situation program involves a continuing appraisal of the current and prospective economic situation for deciduous fruits and tree nuts. Results of these appraisals, findings of special studies, and long-time series of basic data are published in the Fruit Situation, issued 4 times a year, and in brief reviews in quarterly issues of the National Food Situation and the Demand and Price Situation. A comprehensive analysis of the deciduous fruits and tree nuts situation is presented at the Annual Outlook Conference. Outlook presentations also are made at regional or State outlook meetings, meetings of farm organizations, and to various agricultural industry groups. Special

studies are made from time to time to determine probable effect of proposed programs on supply, price and consumption of these commodities. Basic statistical series on stocks, foreign trade, consumption, and price are compiled, improved and maintained for general use in statistical and economic analysis.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

All state experiment stations are engaged in price research to fulfill the needs of farmers, handlers, and processors for information necessary for intelligent production and marketing decisions. The USDA provides much of the basic and background information but more geographic specifics and more detailed analysis is often requested of the experiment stations.

A few private colleges and organizations are engaged in price research and may give attention to agricultural products from time to time.

A substantial number of private organizations--including manufacturers of food and fiber products, private commodity analysis, banks and investment houses--are engaged in commodity outlook work similar to that carried on by USDA. This work, however, frequently relates to shorter time periods than those covered by the Department's outlook appraisals; is predominately for private use; and not available to the public.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Peaches. Work was continued on the analysis of demand for peaches. More analyses of the factors affecting marketing of California Freestone peaches were made, with reasonably good results in explaining prices in the fresh market and for canning. About 70 percent of the price variation in the fresh market was explained, both in postwar and for 1935-58, omitting the war years. Income was an influential factor in prewar but not in postwar years. About 90 percent of the price variation in Freestones for canning was explained for the full period and about 85 percent in postwar years. Income was not important, as was the case in most parts of the study relating to processed peaches.

There doubtless is interaction among prices and quantities of Freestones going to fresh market, canning, drying, and freezing. Measurement of relationships among these end uses of Freestones is difficult because there have been substantial changes in utilization trends in recent years.

Grower prices for Clingstones for canning are best explained by expected supply on June 1 or July 1. Various formulations were tried but none explained more than half of the price variation. It is probable that competing products have an important effect but this has been difficult to measure.

Apples. A summary of apple demand and price analyses published since 1945 was made as part of a comprehensive report on what is known about apple production and marketing being prepared by the Department. Work done outside as well as within the Department is included. The summary points out that more is known about demand for apples, and the statistical measures often are more precise, than for many other fruits and that prices of apples are more responsive to changes in supply than prices of some fruits and most other agricultural products. The report suggests that due to the growing importance of canning in recent years, more studies relating to demand interrelationships for processed products and fresh market are needed. A draft of the report is in departmental review.

Production of deciduous fruits in 1961 was about 8 percent larger than in 1960 and 9 percent above the 1950-59 average. Current estimates put the 1962 crop 2 percent below 1961 but 4 percent above average. The reductions from 1961 are in apples, apricots, peaches, plums, and strawberries.

Total production of edible tree nuts in 1961 was a record, 17 percent above the heavy 1960 tonnage. But prospective production for 1962 is 33 percent below 1961 and 13 percent below average. Only walnuts show an increase in 1962.

Approximately 59 percent of the 1961 deciduous fruit crop was processed. Although this percentage was the same as for the 1960 crop, the tonnage processed was larger because of the heavier 1961 crop. This contributed to record 1961 packs of canned and frozen fruits and to an increase in output of dried fruits. Another large pack of canned fruits is expected in 1962, but output of frozen and dried fruits probably will be below 1961.

Although total production of fruits in 1961 was moderately larger than in 1960, season-average prices received by growers for several fruit crops, notably sour cherries, peaches, pears, and grapes, were above prices for the 1960 crops. Strong demand for processing was a contributing factor. With production of most fruit crops also large in 1962 and processor demand not so strong, grower prices early in the 1962 season have tended to average below 1961 levels.

A study of the peach economy since 1935 showed, (a) a moderate but irregular upward trend in production; (b) a striking shift in emphasis from fresh use and drying to canning; and (c) a moderate increase in total consumption of peaches, but a small decline in per capita consumption.

A statistical study of Hawaiian fruits and tree nuts showed: (a) that the value of production of fruits and tree nuts in Hawaii in 1959 was about 3 percent of the value of production on the mainland that year; (b) that pineapple was the major item, the most of which was shipped in processed form to the mainland; and (c) that pineapple comprised about 5 to 6 percent of total fruit consumption on the mainland during the past decade.

An analysis of trends in the production and use of both sweet and sour cherries since 1938 indicated: (a) increased production of sweet and sour varieties during the 1940's, thereafter no marked trends, though output of sour was at a higher level than that of sweet; (b) declines in fresh use, increases in processing, especially in sweet cherries brined and in sour cherries frozen; and (c) increases in both total and per capita consumption of cherries until 1950, then declines.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

- FitzSimmonds, R. S. October 1962. U. S. Foreign Trade in fruit. Fruit Situation.
- Pubols, B. H. Fruit Situation. Published quarterly. ERS, USDA, Washington, D. C.
- Pubols, B. H. January 1961. A half century of fruit consumption. Fruit Situation.
- Pubols, B. H. June 1961. A quarter century of peaches. Fruit Situation.
- Pubols, B. H. June 1962. Trends in cherry production and use. Fruit Situation.

CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--
HOUSEHOLD AND INDUSTRIAL
Standards and Research Division, SRS

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increase returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine: attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

The work of the Branch is carried out in cooperation with other Federal governmental agencies, divisions within the Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land grant colleges, agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D.C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years, of which 1.4 were devoted to deciduous fruit and tree nuts.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Agricultural Experiment Stations. The Stations do not report any of their work under this heading. However, they do have a considerable program in the area of consumer buying and use practices and motivation and decision making. This includes some research in preference and quality discrimination. There is a reference to parts of the Stations' program in other division reports.

Industry and Other Organizations conduct research in this area, but the research done by individual firms and organizations is almost without exception for their exclusive internal use. There are very few instances in which the findings are made public or made available for government reference. In addition to the research actually initiated and paid for directly by industry, a substantial amount is undertaken in their behalf as part of the service provided by their advertising agencies.

Producer Groups. A number of food producer groups conduct consumer preference work with their own staff and, in addition, contract for research with private marketing firms. To a large extent, this research is limited to food classes such as poultry, dairy products, citrus and deciduous fruits (rather than being directed to individual branded products). This research ranges from a small to national coverage. It includes taste testing for quality differentiation, new product acceptance, and attitudes toward existing products.

Food Processors. In the livestock industry most of the larger packers have research programs for evaluating the effect of product change and acceptance of new meat products. A sizeable number of other food processors have extremely large programs of consumer research. They are engaged in work on new food forms and convenience foods such as cake mixes, canned and frozen fruits and vegetables, deciduous fruits, citrus fruits, soups, dairy products, and alcoholic beverages.

Miscellaneous Groups. There is a smaller but constant amount of research undertaken by magazines and publishing houses for their principal advertisers. A number of the largest retail stores in our major cities study the consumers' reactions to their merchandise and service by conducting interview studies with customers and noncustomers. One of the largest food retailing chains has an active program in quality research which involves taste testing as well as consumer preference. Estimated annual expenditures for research related to agricultural commodities and nonagricultural products in competition with them are equivalent to approximately 20 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A final report is being prepared for publication on a study to determine consumer acceptance, on a commercial trial basis, of a superconcentrated apple juice developed by the Eastern Utilization Research Laboratory. Results of the market test conducted in Ft. Wayne, Indiana, in cooperation with the Economic Research Service and the Michigan State Apple Commission, indicated that about 11 percent of the households in the area purchased the test product during the period of study. Most of the purchasers were new to the use of apple juice. Both the favorable reactions of users and reported interest in future purchases suggested that the test product might well achieve a favorable reception in competitive markets.

A contract was recently signed with a private research firm to conduct a study on selected noncitrus fruits such as apples and peaches. Substantial shifts have occurred in the past two decades toward the use of processed as opposed to the use of fresh fruits. Interviews with a nationwide probability sample of homemakers will ascertain the present pattern and frequency of use of selected noncitrus fruits, and the attitudes and opinions which influence use or nonuse.

IMPROVEMENT OF CROP ESTIMATING PROCEDURES

Standards and Research Division, SRS

Problem. The Statistical Reporting Service produces a large number of current statistics pertaining to agriculture. Because of limited resources, statistical methods were devised with a view to producing the most information for the least cost. These methods are subjective in nature and are based largely upon self-selected samples from voluntary crop reporters, who fill out and return mailed questionnaires. The information is generally collected in the form of relatives such as acres this year compared to last, and crop condition as a percentage of full crop. Persistent bias is removed by charting and census or other check data are generally projected to form current estimates. Estimates based on these sample methods have proved relatively satisfactory over the years. However, in seasons when changes are unusually large the changes may not be fully reflected in the appraisals and reports of the respondents to mailed questionnaires. In situations like this, when accuracy is needed most, the estimates may lack the required precision. Then, when the estimates are translated into available supplies for the different commodities, price inequities may occur and, as a result, producers or the processors of agricultural commodities may suffer serious financial loss.

With the development of modern statistics, new methods based upon probability sampling have been developed. Although surveys based upon probability sampling are more expensive to conduct than the traditional self-selecting mailed survey, these new methods offer a means of increasing the precision and reliability of the estimates. A properly designed well-conducted sample survey can produce unbiased estimates which have the desired levels of precision and reliability. Because of the need by the agricultural economy for high quality statistics, it is mandatory that the statistical theory and methods be developed and adapted to the needs of SRS. Some of the new procedures have already been introduced but there is an urgent need for a continuing research to devise efficient survey methods so as to make possible continuing improvement in the quality of SRS statistics.

USDA PROGRAM

The Department conducts a program of applied research designed to strengthen and improve the methodology used in collecting agricultural statistics. The principal disciplines involved are mathematics, statistics and probability, but other disciplines relating to a particular problem are brought to bear as required. Examples of these are plant physiology, psychology, cartography and photogrammetry. The current program consists of 5.0 professional man-years per year devoted to the study of sample and survey methods and 4.0 professional man-years

working on methods for forecasting and estimating the yields of important crops. Work under this program is done in Washington, D. C., and in SRS field offices located in the states concerned.

Objective forecasting procedures are being developed for grapes and cherries; .5 Federal professional man-year is utilized.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Work of State Experiment Stations in this area is not available for individual commodities. A number of industries serving agriculture collect information for their use, but this is usually based upon field men's observations and there is no program of related research being conducted. A number of State agencies and a few industry groups cooperate with the Department by supplementing Department resources in order to extend scope or frequency of reports so there is little need for research in crop estimating methods outside the Department which is independent of the Department's program.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Sour Cherries. During 1961, objective sampling of cherries was continued in 135 orchards in Michigan. The number of sample orchards in the pilot surveys was such that more reliable estimates of sampling variation and studies by several maturity categories could be made with the data collected. The analysis of weight per cherry by maturity groupings based on days since bloom indicates a definite relationship. Additional studies will be made using the classification of trees into groups based on days after bloom to develop growth curves suitable for each group. A second phase of the cherry project was concerned with more frequent visits to a group of six orchards to make it possible to obtain more detailed information on growth and droppage. Visits were made every three days when the droppage and weight was changing rapidly. Observations of bloom, leaf development and hardening of pit were also obtained to provide a basis for a more precise determination of the droppage and weight curves.

In 1962, the Great Lakes Cherry Producers Association contributed funds for starting the development of a forecasting procedure which would extend the Michigan forecasts to the important producing states in the Great Lakes area. Small pilot studies were initiated in Wisconsin, Pennsylvania, and New York. As was expected, techniques for estimating fruit numbers that were developed in Michigan appeared to work satisfactorily in field tests in these three States. However, significant differences are expected in the droppage and weight parameters and perhaps in the rate of fruit development but the analysis of the data has not been completed.

V. NUTRITION AND CONSUMER-USE RESEARCH

Human Nutrition Research Division, ARS
Consumer and Food Economics Research Div., ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition education programs.

The research is carried out by two Divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Washington, D. C. and at Beltsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 61.1 man-years. It is estimated that approximately 7.6 Federal professional man-years are utilized in studies related to deciduous fruit and tree nuts.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and micro-organisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research is described on a nutrient basis in the report for the Food and Nutrition Advisory Committee. The total Federal effort is 29.5 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Station research in 1961 included 22.4 professional man-years devoted to studies of the inherent properties of foods and of their household use; 17.6 to analyses of a variety of foods for vitamins, various lipid and protein components, and minerals; and 2.7 to studies of food consumption and dietary levels of households and of food management practices. Although the State work has not been reported on a commodity basis, some of the above research is applicable to this report.

Industry and other organizations such as universities and professional organizations are estimated to devote about 36 man-years to research on the preparation of materials for nutrition education, surveys of diets of individuals, and studies of functional properties and stability of food and of their specific nutrient contents. Limited work is done on the amount and structure of nutrients in foods and on compiling food composition data. Again, some of this work is applicable to this report.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Nutritive Values of Foods

1. Tables of Food Composition. Data review has been completed for a revised edition of Agriculture Handbook No. 8, "Composition of Foods.. Raw, Processed, Prepared." This edition will have nearly 2,500 food items as compared with 751 items of the preceding edition, and upwards of 45,000 separate compositional values. For many foods, data will be provided for different forms--raw, cooked, canned, frozen, milled, dried, instant, dietetic, etc. The new publication will have, in addition to other constituents, data for protein, fat, carbohydrate, five vitamins (vitamin A, niacin, riboflavin, thiamine, ascorbic acid), six minerals (calcium, phosphorus, iron, sodium, potassium, magnesium). Explanatory notes for foods and nutrients will be added for users of the tables. Information on cholesterol and fatty acids will also be included.

Special attention has been given to bringing together and summarizing all data available on the deciduous fruits commonly used in this country, and all data available for the tree nuts to be used here. The new edition of Handbook 8 will contain information for deciduous fruits and fruit products subdivided on the basis of factors affecting content of nutrients. In the case of apples, for example, data will be shown separately for fresh and for stored apples. Other apple products in the table will be canned, dehydrated, dried, frozen, and apple juice. A total of about 90 deciduous fruit items will be included. Berries, grapes, and other types of fruit and their products will add some 70 items to the table.

Tree nuts and their products for which data will be included in the new edition total about 25 items.

2. Vitamin Analyses. Values more representative of the vitamin B₆ content of foods now may be obtained by use of a method recently developed at Beltsville, Maryland. Separation by column chromatography of the three forms of vitamin B₆ naturally occurring in foods permit each form to be assayed individually. Values derived from these data for total vitamin B₆ approximate closely values obtained from rat bioassay.

Research is in progress to combine a number of steps in the determination of various B-vitamins in order to facilitate their simultaneous analyses, permit complete characterization of the B-vitamins in foods and to determine their overall distribution in the food supply.

Strawberries averaged .54 micrograms of vitamin B₆ per gram, 60 percent of which was pyridoxal. Other fruits and tree nuts will be included.

3. Mineral Analyses. Apples, grapes, peaches, pears, strawberries, blueberries, raspberries, dewberries, cherries, nectarines, plums, cantaloup, honeydew, watermelon, rhubarb and dried apricots, prunes, raisins and dates are included in the 150 lots collected for the determination of mineral elements in these fruits. At least four lots of each fruit from the major producing area or areas of these fruits available on the Washington, D. C., market have been procured. The collection of some 50 additional lots is indicated. Yield of edible portion, and preparation of all samples for analysis is complete. Chemical analyses are more than half completed.

4. Proximate Composition. Determination of the proximate composition of foods, i.e., moisture, fat, kjeldahl nitrogen and ash, were carried out in conjunction with studies for other nutrients in foods such as the vitamins, mineral elements, fatty acids and carbohydrates. Such an arrangement added to the information on composition of foods in the various commodity groups and also permitted the calculation of nutrients on a fat free-moisture free basis or on a nitrogen or portein basis where relationships among nutrients were concerned.

Moisture, total sugars, reducing sugars, sucrose and total titratable acidity were determined in the following sample lots: 31 apple, 4 honeydew, 9 cantaloup, 15 pear, 22 peach, 7 blueberry, 5 grape, 8 nectarine, 4 plum and 17 strawberry. These are part of the fruits obtained from different production areas for mineral element analyses. The studies are continuing.

B. Food Properties Related to Quality and Consumer-Use

Preparation time, serving yield, color, flavor and texture of different market forms of deciduous fruits were determined as part of a cooperative study with the Economic Research Service. Information on additional samples of frozen sliced peaches, red raspberries and sliced strawberries from local retail markets was obtained to provide a base-line for planning studies on household handling of frozen foods. Selected brands of the fruits were purchased from selected stores and each brand-store combination was replicated four times each season for four consecutive seasons. A large proportion of samples were of high table quality. However, there was considerable variation in quality of all fruits, as shown by ranges in all criteria studied--ascorbic acid-oxidation ratios; solids-to-liquids ratios of ascorbin acid, titratable acids and soluble solids; and panel scores for color, texture and flavor. Manuscripts of the findings are in preparation.

The fruits studies were: Fresh - dark sweet cherries, red sour cherries, cranberries, peaches, plums, red raspberries, rhubarb and strawberries; Canned - baked apples, dark sweet cherries, red sour cherries, cherry sauce, cranberry sauce, peach halves, plums, red raspberries, whole strawberries and strawberry pie filling; Frozen - sliced peaches, red raspberries, sliced strawberries, baked apples, red sour cherries and rhubarb.

C. Food Economics and Diet Appraisal

1. Food Consumption and Dietary Levels. Information on the nutritive value of the food consumption of households based on the 1955 survey data has been summarized in Report No. 16 of the 1955 Household Food Consumption Survey series. Average family food supplies for a week in 1955 were sufficient to provide more than the National Research Council's recommended allowances for calories and eight nutrients for which values

were calculated. However, many households (48 percent) had diets that did not fully meet the allowances in one or more nutrients. Other analyses of survey data show the relation of family size, the education of the homemaker, and of income to the food consumption of households. Because of interest in information on quantities of foods used by high consumers as well as average consumers estimates were made for some 60 food items of the ninth decile--the figure dividing the highest 10 percent of the consumers from the lowest 90 percent. For deciduous fruit and tree nuts the amount consumed per person in "high consumption" households was 1.5 to 3.5 times as much as in "average consumption" households.

Two surveys were conducted cooperatively with the Marketing Research Division, Economic Research Service in Detroit, Michigan and Fayette County, Pennsylvania to provide evidence on the extent to which food consumption is increased and diets improved as a result of the Food Stamp Program.

A report of the food consumption and dietary levels of a group of older, low-income households in Rochester, New York, is in preparation.

Work is being undertaken on food consumption and nutritive content of diets of individuals. A systematic review and summarization of quantities of food consumed is being made through a cooperative agreement with the Minnesota Agricultural Experiment Station. A similar review of the nutritive content of the diets of individuals is being made by Washington staff.

The nutrient content of the per capita food supply, calculated each year, using data on retail weight quantities of food as developed by the Economic Research Service, provides the only source information on year-to-year changes from 1909 to date.

2. Food Management Practices. Information on the kinds, amount, and nutritive value of foods used and discarded in households has been obtained in a series of small studies. Results will help to evaluate survey data on household food consumption.

A report on household practices in handling and storing of frozen food has been prepared, based on surveys in Baltimore, Maryland, and Indianapolis, Indiana. Households provided information on the length of time frozen food was held in home storage, and the temperature of the compartment in which frozen food was being held at the time of the interview.

3. Development of Food Budgets and Other Basic Data for Food and Nutrition Programs. An important aspect of nutrition research is the interpretation and application of research findings to practical problems of food selection in relation to health. An ongoing program of work includes assembling and interpreting available information on nutritional needs, food consumption, and nutritional value of foods for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education programs.

A technical report explaining the development of the food budgets, "Family Food Plans and Food Costs," has been completed and is in press. Another in the series of popular publications on food management has been prepared, "Food for the Young Couple." A publication "Family Food Budgeting...for good meals and good nutrition," designed to help families of all sizes is also being prepared.

Regular pricing of family low-cost, moderate-cost, and liberal food plans is published in Family Economics Review on a quarterly basis for the U. S. average and on an annual basis for the regions and the low-cost food plan for the South. Each plan gives suggested quantities of food that will meet nutritional needs for each of 17 age and sex groups and for women during pregnancy and lactation so that household or population totals may be obtained.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides a channel for disseminating pertinent information and for reporting nutrition education activities. A Nutrition Education Conference sponsored jointly by USDA through its Nutrition Programs Service and by the Interagency Committee on Nutrition Education was held in Washington, D. C., January 29-31, 1962.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Nutritive Value of Foods

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Food Properties Related to Quality and Consumer-Use

Human Nutrition Research Division. 1960. Home care of purchased frozen foods. Home and Garden Bulletin 69, 6 pp., illustrated.

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